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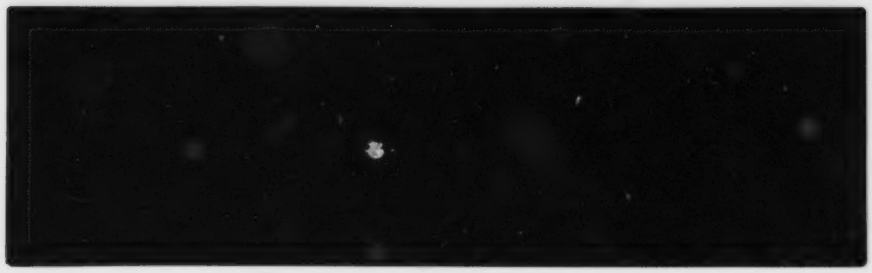

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AN EVALUATION OF RADIATION AND METEOROLOGICAL CONDITIONS IN AN UNDERGROUND URANIUM MINE

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ABSTRACT

A sampling and monitoring program was designed in order to obtain radiation, meteorological and climatic data in an underground uranium mine. The data so collected were analyzed to investigate the relationship between radiation levels and meteorological and climatic variables, as well as between radiation levels and mining activities and operations. The program was also aimed at determining radiation source terms such as radon flux, and at validating a theoretical (radiation) mine model developed to predict radon gas concentration and radon progeny Working Levels in underground uranium mines, and to extend this model to radon/thoron atmospheres. The radiation, and meteorological and climatic variables measured during the monitoring program were the following: radon gas concentration and radon progeny Working Level, thoron progeny Working Level, radon flux, temperature, barometric pressure, relative humidity, airflow conditions, and other variables of interest. The duration of the program was one year. The experimental difficulties encountered in determining radon and thoron flux and validating mine models are discussed.

Key words: Uranium mines; Radon and radon progeny; Thoron and thoron progeny; Radon and thoron flux.

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ÉVALUATION DES RAYONNEMENTS ET DES CONDITIONS MÉTÉOROLOGIQUES DANS UNE MINE D'URANIUM SOUTERRAINE

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RÉSUMÉ

Un programme d'échantillonnage et de surveillance a été élaborée en vue de recueillir des données sur les rayonnements ainsi que des données météorologiques et climatiques dans une mine d'uranium souterraine. On a analysé les données receuillies en vue de déterminer la relation entre les intensités des rayonnements et les variables météorologiques et climatiques, de même qu'entre les intensités des rayonnements et les opérations minières. Le programme visait aussi à déterminer certains paramètres de la source de rayonnement, comme le flux de radon, à valider un modèle de mine (rayonnement) théorique élaboré en vue de prévoir la concentration de radon et les niveaux opérationnels des descendants du radon dans les mines d'uranium souterraines, et à étendre ce modèle aux atmosphères de radon/thoron. Les variables concernant les rayonnements et les variables météorologiques et climatiques mesurées pendant le programme de surveillance étaient les suivantes : concentration du radon et niveau opérationnel des descendants du radon, niveau opérationnel des descendants du thoron, flux de radon, température, pression barométrique, humidité relative, conditions d'écoulement d'air, et autres variables d'intérêt. Le programme a duré une année. Les difficultés expérimentales rencontrées dans la détermination des flux de radon et de thoron et dans la validation des modèles de mines sont décrites.

Mots-clés : mines d'uranium; radon et descendants du radon; thoron et descendants du thoron; flux de radon et de thoron.

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INTRODUCTION

Uranium (^{238}U) minerals are found in abundance in uranium mines. To some extent, thorium (^{232}Th) minerals are also found in relatively high amounts in some uranium mines. These two radionuclides decay through a series of intermediate steps into radon gas (^{222}Rn) and thoron gas (^{220}Rn), respectively. Once formed, these two radioactive gases migrate through mine walls by diffusion and convection (transport) mechanisms into working areas. Radon and thoron decay in turn into their respective short-lived progenies which once inhaled pose an occupational health hazard.

A problem of considerable practical interest is that of predicting radioactivity levels at working sites from some basic characteristics and considerations of the working place. For underground uranium mines, the problem reduces to the calculation of airborne radioactivity levels (radon, thoron and their progenies) as determined from mine geometry considerations, ore grade, ventilation characteristics, physico-chemical properties of the ore-bearing rock, and local meteorological conditions.

As specifically applied to underground uranium mines, prediction of airborne radioactivity levels can be divided into two main parts, namely:

a) Calculation of the emanation of ^{222}Rn and ^{220}Rn from mine walls as related to ore grade, mass gram ratio $^{238}U/^{232}Th$, local meteorological conditions (particularly barometric pressure, aerosol concentration, and aerosol size distribution), and physical charactistics of the ore-bearing rock, such as porosity and permeability; and

b) Calculation of the concentration of ^{222}Rn, ^{220}Rn, and their respective progenies, in mine environments as related to item a), ventilation rate, and losses of radioactive products by plate-out on mine walls.

Items a) and b) are of limited value unless validated by experiment. Verification of (radiation) mine models is of great importance as it permits

confident application of the model(s) to situations of practical interest.

This report presents an analysis of experimental radiation and meteorological data collected by Denison Mines Ltd. and the Elliot Lake Laboratory (CANMET) personnel over a one year period (1986/87). The data are then applied in the context of items a) and b) in an attempt at verifying some aspects of mine models. The experimental data collected by Denison Mines Ltd. are part of a radiation program sponsored by Atomic Energy Control Board (AECB) under contract with Denison Mines Ltd.

EXPERIMENTAL PROCEDURE

A wide variety of mine sampling sites was selected for radiation and meteorological monitoring purposes. This selection was as follows:

1. Main general areas (sections) of the mine;
2. Within each section a number of locations of interest were identified such as exhaust ways, travelways, shafts, main ramps, stopes and leaching areas;
3. Within most locations two or more stations were chosen for reasons described below.

The areas (sections), location and stations chosen were based on the following parameters of interest:

a) emanation characteristics (type);

b) mining activity;

c) ventilation conditions;

d) ground, floor, back and wall conditions;

e) mine water conditions; and

f) unusual conditions.

Items a) to f) are illustrated in detail in Table 1 with their corresponding identification codes.

About 40 locations corresponding to approximately 100 stations were examined. Table 2 shows the locations and stations where measurements were conducted. Also shown in the table is the emanation type code corresponding to these locations.

Underground measurements were divided into four main categories, namely:

i) Radioactivity measurements such as radon gas concentration, [^{222}Rn], radon progeny Working Level, WL(Rn), thoron progeny Working Level, WL(Tn), and radon gas flux measurements, J(^{222}Rn);

ii) Meteorological measurements such as barometric pressure, P, dry bulb temperature, T_D, wet bulb temperature, T_W, and relative humidity, RH, air flow rate, Q, and mine air residence time, RT;

iii) Physical and geometric measurements including cross-sectional area, A, surface area, S, volume, V, and distance, L, between any two points of interest of a mine location, and characteristics of the surface of mine walls (e.g., roughness); and

iv) Observations of interest regarding the physical appearance of working and inactive locations of the mine where measurements were taken, such as water conditions, leaching operations, and the like, as shown in Table 1. Also included in this category are observations pertaining to operation of vehicles, tools and mining equipment.

Determination of the radiation and meteorological variables indicated in items i) and ii) were of the grab-sampling type. Radon gas concentration was measured using ZnS(Ag) scintillation cells and α-particle scalers using a photomultiplier tube in conjunction with its associated electronic circuitry. Radon progeny Working Levels were measured by the Kusnetz method (1). Thoron progeny Working Levels were determined by the Rock and Bigu methods (2,3).

Air samples were collected on 25 mm, 0.8 μm Millipore filters. Each air sample was used to determine WL(Rn) and WL(Tn) by time-delay measurements of α-particle activity according to well established methodology (1,2), see also below.

In the case of WL(Rn), α-particle scalers model Tri-Met 372A manufactured by Tri-Met (Winnipeg, Canada) were used. Measurements of WL(Tn) were made with an automated system consisting of a modified slide carousel, a ZnS(Ag) screen optically coupled to a photomultiplier tube and associated electronic circuitry, and an Apple IIe computer with software and interface cards to drive the carousel automatically, count the α-activity on the filters, and perform the necessary calculations to estimate WL(Tn). The thoron progeny α-particle count was subsequently used to correct the α-particle count corresponding to the Kusnetz measurements in order to obtain the corrected, i.e., true, values of WL(Rn).

Radon gas flux measurements were carried out by the Elliot Lake Laboratory personnel by means of fluxmeters of the can type as described elsewhere (4). Radon gas flux measurements were also conducted by the two point method (2PM). Most of the $J(^{222}Rn)$ measurements were made using this method. The 2PM method consisted in measuring $[^{222}Rn]$ at two different sections of a given location. Calculation of $J(^{222}Rn)$ from $[^{222}Rn]$ is described below. Thoron gas flux measurements, $J(^{220}Rn)$, were estimated theoretically from experimental measurements of WL(Tn) and the ratio WL(Tn)/ $[^{220}Rn]$, as discussed below.

Thoron gas concentration was measured using the two filter tube (2 FT) method as discussed elsewhere (5). This method was also used to measure radon gas concentration when thoron gas concentration measurements were made, using time-delay α-particle measuring techniques.

Meteorological variables such as pressure, P, dry bulb temperature,

T_D, wet bulb temperature, T_W, and relative humidity, RH, were determined by conventional methods, i.e., barometers and hygrometers, respectively. Air flow rate, Q, and mine air residence time, RT, were estimated by anemometry.

The data presented in this report were collected over the period of one year (1986/87). This project was undertaken with three main goals in mind:

A. To evaluate radiation source terms, i.e., radon and thoron gas fluxes;

B. To validate a computer mine (radiation) model for ^{222}Rn and WL(Rn) developed by Queen's University (6) using data from item A);

C. To modify and expand the above model to calculate WL(Tn).

THEORETICAL BACKGROUND

Topics of theoretical relevance and practical interest include: a) radiation modelling of underground uranium mines, and b) identification and quantification of radioactivity source terms in the mine. Item b) is usually defined in terms of the radon (thoron) flux, a variable which appears in the basic kinetic equations describing the growth and decay of radon, thoron and their progenies in underground uranium mine environments. The discussion that follows focuses on the two subjects referred to above.

A. QUANTIFICATION OF RADIOACTIVE SOURCE TERMS - FLUX MEASUREMENTS

Radon gas and thoron gas flux measurements can be made using fluxmeters, or by the '2 point measurement' (2PM) method.

Flux Measurements With Fluxmeters

A fluxmeter consists of a chamber (accumulator or can) where radon gas and/or thoron gas is collected. The accumulator (can) is usually a cylindrically shaped chamber hood with an open bottom end with sharp edges. The accumulator is partly driven into, or cemented to, the material surface where the flux measurements are to be made so as to ensure a good seal

around the contact surface with negligible disturbing effect on the material surface.

Calling S, h, and V(= Sh) the cross-section, height and volume of the fluxmeter, respectively, and J the radon surface flux, N the number of atoms of radon in the volume V at time t, and λ the radioactive decay constant of the radioactive gas, one may write the rate of build-up of radon gas in the accumulator according to the kinetic equation:

$$\frac{dN}{dt} = JS - \lambda N \qquad \text{Eq 1}$$

If the radon gas flux across the material/air interface is assumed to be independent of time, the flux can be calculated from Equation 1 using the boundary conditions:

$$N(t) = N_o \text{ for } t = 0$$

$$N(t) = N(t) \text{ for } t = t$$

Thus,

$$J = \frac{\lambda[N(t) - N_o\, e^{-\lambda t}]}{S(1 - e^{-\lambda t})} \qquad \text{Eq 2}$$

Equation 2 can be written in terms of radon gas concentration, C, taking into account that N = CV. Thus,

$$J = \frac{\lambda h[C(t) - C_o\, e^{-\lambda t}]}{1 - e^{-\lambda t}} \qquad \text{Eq 3}$$

Equation 3 can be simplified if $C_o = 0$ at $t = 0$ and $\lambda t \ll 1$. In this case Equation 3 reduces to the well known expression:

$$J = h\, C(t)/t \qquad \text{Eq 4}$$

If $C_o = 0$ at $t = 0$, but measurements are conducted at $t = \infty$, i.e., $\lambda t \gg 1$, Equation 2 reduces to:

$$J = \lambda h\, C(t\infty) \qquad \text{Eq 5}$$

Equation 4 is the classical accumulator method for determining J. Measurements are conducted during the linear build-up of radon gas in the accumulator, i.e., $\lambda t \ll 1$. Equations 4 and 5 have been derived under the

assumption that J is independent of the radon gas concentration difference between interstitial pore volume below the soil surface and the accumulator volume. However, J is a function of the concentration difference across the soil/air interface. This dependence can be expressed as (7):

$$J = -D(dC/dZ) = \alpha(C_p - C(t)) = \frac{\alpha}{V}(N_p - N(t)) \qquad \text{Eq 6}$$

where the subindex p is used to indicate interstitial pore. Thus, C_p is the radon gas concentration in the interstitial pore below the soil surface. The symbol α is a proportionality constant.

Using Equations 1 and 6 and the boundary condition $C(t) = 0$ at $t = 0$, it can be shown (8) that:

$$J = \beta h\, C(t\infty) \qquad \text{Eq 7}$$

where,

$$\beta = \frac{\alpha}{h} + \lambda$$

The variables β and $C(t\infty)$ can be obtained experimentally using different analytical expressions depending upon the method of measurement employed (4).

It is not difficult to show that Equation 7 reduces to Equation 5 if J is assumed to be independent of interface radon gas gradients, as in this case $\alpha = 0$ and hence, $\beta = \lambda$.

Equation 7 represents a significant improvement over the methodologies suggested by Equations 4 and 5. However, it still has a major drawback, namely J is assumed to be diffusion controlled and hence pressure-induced convective flow of radon gas across the interface is ignored.

Radon (thoron) gas concentration measurements in the accumulator can be made by manual means or by automated, continuous α-particle counting systems as described in the literature (4,9-13). In the present case, fluxmeters were installed on the mine walls at several locations and radioactive gas samples were taken in scintillation cells to determine the radon gas concentration. Samples were taken and measured over a period of

several months to ensure measurements at steady-state conditions, i.e., $\lambda t >> 1$, according to Equation 5.

Flux Measurements by the Two-Point Measurement (2PM) Method

Flux determinations can also be made by measuring the radon (thoron) gas concentration at points on two different cross-sections of the mine a known distance apart. Calculation of the flux can be made using several mine models developed under different basic assumptions. The kinetic equation describing the growth and decay of ^{222}Rn, ^{220}Rn and their progenies in underground uranium mines using different mine models have been given elsewhere (14). Using the same terminology as before one may write the basic kinetic equation for radon or thoron gas in an underground uranium mine as follows:

$$dN_n/dt = Y - X_n N_n \qquad \text{Eq 8}$$

where N refers to the atom concentration and the index n is used to indicate radioactive gas, i.e., radon or thoron. The parameters Y and X_n describe, respectively, the production and removal of radioactive gas. These parameters assumed different forms depending on the particular model under consideration (14). Integration of Equation 8 permits calculation of J, the flux, as indicated below. Expressions are given below for N_n and J for several mine models chosen for the determination of J.

1. Thomas-Epps Mine Model (TEMM)

It can be shown that (15):

$$N_n\lambda_n = [n] = J_nS/Q \qquad \text{Eq 9}$$

where [n] is used to indicate radon or thoron gas concentration. If [n] measurements are conducted at two different cross-sections of the mine and $\Delta[n]$ represents the difference in [n] at these two different cross-sections (i.e., points), it is easy to write from Equation 9:

$$J_n = \Delta[n]Q/S \qquad \text{Eq 10}$$

where in the above equations Q stands for air flow rate, and S stands for the radon (thoron) emanating surface area corresponding to the volume of the mine under consideration.

2. Modified Thomas-Epps Mine Model (MTEMM)

Because of the long radioactive half-life of ^{222}Rn, i.e., ~3.8 d, and the relatively short residence times (RT) of mine air in any mine volume, usually a few minutes, the TEMM is accepted as a fair description of the N_n in a mine volume. This model however, is not suitable for thoron, a radioactive gas with a very short half-life (~55 s). Bigu (14) has modified the TEMM to make it applicable to the thoron gas case. The resulting model is referred to here as the Modified Thomas-Epps Mine Model (MTEMM). It can be shown that:

$$N_n = \frac{J_n P}{A \lambda_n^2} (1 - e^{-\lambda_n t}) \qquad \text{Eq 11}$$

where P is the perimeter and A is the cross-section of the mine volume, V, under consideration.

It is easy to show that

$$J_n = \frac{\Delta[n] \lambda_n V}{S(1-e^{-\lambda_n t})} \qquad \text{Eq 12}$$

It is not difficult to show that for small enough values of $\lambda_n t$ Equation 12 becomes Equation 10.

3. Mine Tunnel Model with Ventilation (MTMV)

This model has been investigated by Beckman and Holub for the ^{222}Rn case (16). The model has been extended by Bigu (14) to deal with ^{220}Rn and $^{220}Rn/^{222}Rn$ mixtures. It can be shown (14) that:

$$N_n = (N_n)_o e^{-\Lambda_n t} + \frac{JS}{\Lambda_n} \left(1 - e^{-\Lambda_n t}\right) \qquad \text{Eq 13}$$

where, $(N_n)_o$ is the initial radioactive gas concentration at t = 0. The

variable Λ_n is given by:

$$\Lambda_n = \lambda_n + O/V \qquad \text{Eq 14}$$

Hence,

$$J_n = \left\{ \frac{[n]_2 - [n]_1 \, e^{-\Lambda_n t}}{S(1 - e^{-\Lambda_n t})} \right\} \Lambda_n V \qquad \text{Eq 15}$$

where the indices 1 and 2 are used to indicate gas concentration measurement at the first and second cross-sections of the mine volume under consideration, respectively.

If $(N_n)_o = 0$ at $t = 0$, it is easy to show that J_n reduces to a solution of the same form as that given by the MTEMM, namely:

$$J_n = \frac{\Delta[n] \, \Lambda_n V}{S(1 - e^{-\Lambda_n t})} \qquad \text{Eq 16}$$

except that λ_n in MTEMM becomes Λ_n in the MTMV.

Thoron flux determination requires thoron gas concentration measurements at two points a distance apart (2PM method), or alternatively, direct wall emanation measurements by the fluxmeter can method.

Because of the short half-life of ^{220}Rn (~55 s), thoron flux measurements in the presence of radon gas by the fluxmeter can method are rather difficult, and beyond the scope of the original underground radiation monitoring program. Thoron gas concentration measurements necessary for thoron flux determination by the 2PM method were, however, not carried out as part of the original monitoring program. Hence, in order to obtain typical values for the thoron flux, a series of separate measurements was conducted after the monitoring program had been completed. The experimental procedure followed is indicated below.

Two locations of widely different air flow characteristics and mining conditions were selected and measurements were conducted at two fixed stations in each location. These pairs of stations in each location were used to determine the thoron flux by the 2PM method using the mine models

discussed above and measurements of thoron gas concentration, $[^{220}Rn]$, by the two filter tube (2FT) method (5), and airflow rate, Q. (Concurrent measurements of the thoron progeny Working Level, WL(Tn), were also conducted at each station within each location for reasons indicated below.) These data made calculation of the thoron flux possible providing, therefore, a first hand measurement of thoron flux for the first time.

Because measurement of thoron gas concentration at each station was not anticipated as part of the original monitoring program, values for the thoron flux could not be obtained at mine stations other than those selected above unless some radiation variable measured at each station during the monitoring program could be used to derive the corresponding value of $[^{220}Rn]$ at this station. A likely candidate was WL(Tn). The next logical step was to see whether a relationship between WL(Tn) and $[^{220}Rn]$ could be obtained which was reliable and constant enough, to be suitable for general use. If such a relationship could be obtained, values for $[^{220}Rn]$ could be derived from experimental measurements of WL(Tn), and hence, the thoron flux could be determined by the 2PM method. The idea behind simultaneous, concurrent measurement of $[^{220}Rn]$ and WL(Tn) was precisely to see if such a relationship existed.

From the data obtained at the two locations referred to above it seemed clear that the following ratio was reliable enough for use: $WL(Tn)/[^{220}Rn] \sim 2 \times 10^{-3}$. It should be noted that, as for the case of the F-value for radon/radon progeny (i.e., $F = WL(Rn)/[^{222}Rn]$), the above ratio is expected to vary with air flow conditions, which affect the state of equilibrium between ^{220}Rn and its progeny, and between ^{212}Pb and ^{212}Bi, and the aerosol concentration (N) which affects the plate-out of thoron progeny on mine walls and other large surfaces.

The effect of airflow, Q, on the ratio $WL(Tn)/[^{220}Rn]$ can be

calculated on theoretical ground (14). The effect of aerosol concentration on the same ratio is, however, rather difficult to estimate theoretically and experimentally. Because of the above, thoron flux calculations based on values of [^{220}Rn] derived from measurements of WL(Tn) are subject to some degree of uncertainty which cannot be ascertained at present but which should be the subject of further investigation.

Flux measurements by the 2PM method and the fluxmeter can method present in each case a number of experimental problems difficult to solve, particularly for ^{222}Rn/^{220}Rn mine atmosphere mixtures. This is so because of the difficulty in discriminating radon and its progeny from thoron and its progeny unless use is made of α- and/or γ-spectrometric techniques. Some specific problems associated with each flux determination method are discussed below. An in-depth discussion on the subject is, however, beyond the scope of this report.

The most serious problems associated with the fluxmeter can method are as follows:

a) radon and thoron back diffusion;

b) leaks at the can/wall interface;

c) dilution or contamination of the radioactive gas in the can when drawing a sample for measurement. Dilution occurs when the radon (thoron) gas concentration outside the can is lower than the corresponding concentration inside the can. The converse is equally true;

d) pressure differential, i.e., vacuum or suction, created when drawing a sample from the flowmeter can by means of an evacuated scintillation cell or a sampling pump. The pressure differential created has the effect of stimulating the emanation of gas from the mine wall. This effect increases with certain physical characteristics of the material

such as porosity. Item d) does not apply to fluxmeters that use, say, activated charcoal or track-etch detectors instead of the conventional transfer of a radon (thoron) gas sample from the can to a scintillation cell.

The main difficulty with the 2PM method of flux determination is a theoretical one. It arises with regard to the range and limit of applicability of the equations derived for the calculation of the flux. An example will illustrate this point. Taking the simplest model used here, i.e., the TEMM, Equation 10 states that the flux is proportional to the ratio $\Delta[n]/S$, However, it has been shown (see reference 14 and Figures 1 to 5) that for an underground mine the concentrations of radon, thoron and their respective progenies increase from zero at $t = 0$, at the origin, to a maximum, constant value when steady-state conditions are reached at a distance from the origin for which the rate of growth of radioactivity equals its rate of decay. The distance from the origin at which this condition occurs depends on air flow conditions, i.e., mine air residence time, and the particular radioisotope under consideration. It has been shown that radon and its progeny behave quite differently to thoron and its progeny.

From the above discussion it can be surmised that for distances equal to or greater from the origin than a given value, [n] does not increase any more, and remains, therefore, constant. Hence, while S (the surface area of the mine between two given points) increases proportionally (linearly) with the distance between the two points, $\Delta[n]$ may attain a constant value or even become zero if the two reference points are both beyond the 'critical' distance for which [n] has already reached the maximum, constant value.

Similar, although not identical, problems may arise when using other mine models. The result is that if measurments are not carried out within the range and limit of applicability of each mode, potentially large errors

in the estimation of the flux may occur. To the knowledge of the author, this subject has not been thoroughly, or even superficially, investigated.

The limits of applicability of a given mine model to the calculation of flux are expected to differ for radon gas and thoron gas. Other problems and observations regarding the 2PM method and the fluxmeter can method are briefly outlined below.

It should be noted that strictly speaking the 2PM method gives 'apparent' values for the flux only as opposed to true emanation flux from mine walls as measured by the fluxmeter can method. This is so because radon gas sources other than those from mine walls also contribute to the radon gas concentration measured in the mine volume. Several discrete (local) sources of radon, in addition to extended, i.e., uniformly distributed, radon sources contribute to the total radon gas concentration observed in the mine. Some of these discrete (local) sources are listed below:

a) radon gas dissolved in water percolating through mine walls;

b) radon gas dissolved in water entering mine openings;

c) radon gas released in local underground uranium leaching operations and uranium leaching by natural processes;

d) radon gas 'pushed' by vehicles into a particular area from adjacent sites; and

e) radon gas released in rock breaking operations and other mining operations such as blasting, drilling, mucking and ore transportation.

Discrete (local) radon sources in the mine may lead to flux measurements by the 2PM method differing substantially from radon flux measurements by the fluxmeter can method. It cannot be sufficiently emphasized, however, that the 2PM method, as indicated above, provides apparent radon flux only, whereas direct wall flux measurements such as those

by the fluxmeter can method provide 'true' measurements that can be used directly as input variables in the kinetic equations of conventional mine models describing the growth and decay of radon and its progeny in underground uranium mine environments (14,17-19). By its very nature, the contribution to the radiation level in the mine from discrete sources of radon cannot be quantified easily using simplistic mine models. The same arguments that apply for radon gas apply equally well to thoron gas.

Finally, for the sake of clarity, some of the terminology used above is explained below. The word,wall,is used in the context of this report to indicate mine surface in general, and as such it is meant to include the roof and floor in addition to the walls proper. Furthermore, the term, extended source, is used here to indicate the more or less uniform distribution of ^{238}U and ^{232}Th throughout the mine, and hence, the uniform emanation of ^{222}Rn and ^{220}Rn from mine walls, respectively. Discrete sources are those of a very localized nature such as the examples given in items a) to e).

B. RADIATION MODELLING OF UNDERGROUND URANIUM MINES

A detailed discussion of radiation models for underground uranium mines has been presented elsewhere (14,17-19). For a comparison of the different mine models discussed the reader should consult the above references, and references therein.

One major goal of the present study was to verify experimentally the validity of a ventilation/radiation mine model developed by Notley et al. (Queen's University, Kingston, Ontario, Canada) based on a radiation mine model investigated by Schroeder and Evans (6,20). The model, known as VENTRAD, was developed under contract with the Atomic Energy Control Board (AECB, Ottawa, Canada). Basically, VENTRAD permits calculation of [^{222}Rn]

and WL(Rn) from ^{222}Rn flux, airflow conditions, and mine geometric considerations. The model in its present stage of development makes no provision for thoron and its progeny and is, therefore, severely limited for practical application in underground uranium mines where thoron is present in appreciable amounts. This includes Ontario mines among other mines in North America and other parts of the world.

Another goal of the study was to expand VENTRAD to deal with radon/thoron mine atmospheres. However, because of the structure of the program, the basic kinetic equation used and the assumptions made, modification of VENTRAD to include thoron and its progeny is rather difficult. In view of these difficulties, the emphasis was shifted here to include thoron in VENTRAD indirectly, i.e., through the ratio WL(Tn)/WL(Rn), or by means of a correlation between these variables of the form WL(Tn) = f(WL(Rn)). In either case, WL(Tn) could be calculated from the value of WL(Rn).

In order to use the ratio WL(Tn)/WL(Rn), this ratio should either be constant or at least predictable. It has been shown that WL(Tn)/WL(Rn) depends mainly on the mass ratio $^{238}U/^{232}Th$ and on air flow conditions (14), hence, the above Working Level ratio is predictable and could be used for the intended purpose. (It should be noted that the mass ratio $^{238}U/^{232}Th$ can be considered a constant for large volumes of the mine.)

Alternatively, one may use WL(Tn)=f(WL(Rn)) to obtain WL(Tn) from experimental values of WL(Rn) provided a reasonably good correlation between WL(Tn) and WL(Rn) can be found suitable for practical applications. In order to do this, experimental data for WL(Rn) and WL(Tn) were examined by standard statistical analysis techniques using the least squares method. The results of this analysis are presented in the section Experimental Results and Discussion.

Finally, the equations used in VENTRAD for the calculation of [^{222}Rn]

and WL(Rn) are given below for the sake of completeness (20):

$$[^{222}Rn] = JPT/A \quad Bq/m^3 \qquad \text{Eq 17}$$

where, all the variables have been defined before, and T is the time elapsed. It is easy to see that Equation 17 is identical to Equation 9 (Thomas-Epps Mine Model, TEMM).

The radon progeny Working Level is given as a three part contribution (20), namely:

$$WL(Rn) = WL(Rn)_1 + WL(Rn)_2 + WL(Rn)_3 \qquad \text{Eq 18}$$

where,

$$WL(Rn)_1 = F\ WL_o \qquad \text{Eq 19}$$

$$WL(Rn)_2 = 6.216 \times 10^{-6}\ [^{222}Rn]_o\ T^{0.85}, \text{ and} \qquad \text{Eq 20}$$

$$WL(Rn)_3 = JPKT^{1.85}/1.85\ A \qquad \text{Eq 21}$$

where, WL_o is the initial value of WL(Rn) at the origin;

$[^{222}Rn]_o$ is the initial value of $[^{222}Rn]$ at the origin; and

K is 6.216×10^{-6} $WLm^{-3}/Bq\ min^{0.85}$

The symbol F in Equation 19 stands for:

$$F = [(G+T)^{0.85} - T^{0.85}]/G^{0.85} \qquad \text{Eq 22}$$

where,

$$G = (43.48\ Er)^{1.1765} \qquad \text{Eq 23}$$

$$Er = 3.7 \times 10^3\ WL_o/[^{222}Rn]_o \qquad \text{Eq 24}$$

It should be noted that the behaviour of the Schroeder and Evans model on which VENTRAD is based, as well as a number of other mine models, has been studied, and extended to the thoron case by the author (14). It is also worthwhile noticing that the Schroeder and Evans model is very similar to the TEMM and MTEMM. Some thoron/thoron progeny theoretical data obtained with the Mine Tunnel Model with Ventilation (MTMV) are presented below for illustration purposes (see Figures 1 to 5). Radon and radon progeny data obtained with the same model have been presented elsewhere (14,17-19).

Figures 1 to 3 show thoron gas concentration, thoron progeny concentrations, and WL(Tn) as a function of time for three different mine

air residence times (RT), namely, 5 min, 15 min, and 90 min, respectively. Figure 4 shows WL(Tn) versus time (up to 60 min) for a number of mine air residence times ranging from 0.5 min to 360 min. Figure 5 is essentially the same as Figure 4 except that WL(Tn) is plotted for times up to 800 min.

Figures 1 to 3 show that ^{220}Rn and ^{216}Po increase very rapidly soon attaining a steady-state, or equilibrium level. The radioisotopes ^{212}Pb and ^{212}Bi, however, increase much more slowly reaching a steady-state at a much later time. These differences can be understood on the basis of the short half-lives of ^{220}Rn (54.5 s) and ^{216}Po (0.16 s) as compared with the relatively long half-lives of ^{212}Pb (10.6 h) and ^{212}Bi (60.5 min).

Because the major contribution to WL(Tn) comes from ^{212}Pb (i.e., ~90%), the thoron progeny Working Level follows the same pattern of growth as ^{212}Pb. The rate of growth, the maximum radiation level reached under steady-state conditions, and the time at which this equilibrium condition is attained for WL(Tn) and the thoron progeny, are highly dependent on mine air flow conditions, i.e., mine air residence time. This is clearly shown in Figures 4 and 5 for WL(Tn).

EXPERIMENTAL RESULTS AND DISCUSSION

For the sake of simplicity and because of the complexity of the subject, the presentation and discussion of the results will be divided into the following main sections:

1. The underground radiation and meteorological environments;
2. Radon gas and radon progeny measurements;
3. Thoron gas and thoron progeny measurements;
4. Radon gas and thoron gas flux measurements;
5. Seasonal variations of the radiation and meteorological underground environments - their relationship;

6. Relationship between mining activities and radiation conditions;
7. Prediction of radiation levels by VENTRAD; and
8. The thoron problem and other problems.

The results obtained and the analysis of the data have been summarized in Tables 3 to 18, Tables A1 to A6, and Figures 1 to 35.

1. THE UNDERGROUND RADIATION AND METEOROLOGICAL ENVIRONMENTS

The radiation and meteorological environments have been summarized in histograms shown in Figures 6 to 15. These histograms show, among others, the following variables and ratios: $[^{222}Rn]$, WL(Rn), WL(Rn)/$[^{222}Rn]$, WL(Tn), WL(Tn)/WL(Rn), T (temperature), P (barometric pressure), and Q (air flow).

Figures 6 to 15 provide a broad, general picture of underground conditions during the period 1986/87. The histograms include data from all locations and stations where measurements were taken during the above period. The histograms show frequency distributions, i.e., normalized number of measurements for a fixed, arbitrarily narrow range of values of the variable of interest versus increasing values of the variable. Normalization is done by dividing the number of measurements within each range by the total number of measurements available over the entire range of values. The range corresponding to each bar is from the value indicated at the bottom of the bar to the value indicated at the bottom of the next bar and so on.

Figure 6 shows that the majority of the measurements for the radon gas concentration were in the range 5-40 pCi/L or 185-1480 Bq/m^3. A significantly smaller contribution appeared in the range 75-100 pCi/L (2775- 3700 Bq/m^3).

The values for WL(Rn) were mostly confined in the range 0.1 to 0.2 as shown in Figure 7, whereas the values for WL(Tn) were spread over a much wider range (see Figure 10).

Figure 8 shows the ratio (WL(Rn)/$[^{222}Rn]$) x 10^2, also known as the F-

factor. This factor is a measure of the age of mine air. A value close to unity (i.e., F~1) represents near equilibrium conditions between radon gas and its progeny, and hence very old mine air. A value F = 1 is only achievable in theory and represents infinitely old air. The experimental values obtained for the F-value were mainly in the range 0.1 to 0.7 with a maximum between 0.2 and 0.4. This range of values for F is in agreement with other measurements in this and other underground uranium mines.

Figure 9 shows the thoron gas concentration, [^{220}Rn], distribution. A wide spectrum of values was obtained, mostly below 100 pCi/L (3700 Bq/m^3). However, values in excess of 200 pCi/L (7400 Bq/m^3) were measured in a number of stations within a given mine location (see below).

Figure 10 shows the thoron progeny Working Level, WL(Tn), distribution. Values up to or higher than 0.8 were measured in a few cases. However, the bulk of the data was in the range ~0 to 0.3 with a maximum between 0.1 and 0.2.

Figure 11 shows the ratio WL(Tn)/WL(Rn). A wide range of values for this ratio was obtained, namely from less than 0.1 to higher than about 7. Most of the values were, however, below 2. The ratio WL(Tn)/WL(Rn) is a good measure of the ventilation conditions in an underground uranium mine. This ratio increases with increasing air flow conditions as discussed elsewhere (14).

Figure 12 shows the air temperature underground. Although a relatively wide range of temperatures was measured (10 to 20^{o}C), the average temperature were in the approximate range 12 to 18^{o}C with a maximum between 14^{o}C and 16^{o}C.

Relative humidity conditions underground varied between 50% to saturation (~100%) as shown by Figure 13. Two major peaks, i.e., 50-70%, and 85-100%, appear in the graph which suggests seasonal conditions, i.e.,

winter and summer, respectively.

Figure 14 shows underground air flow conditions, which ranged from about 5 m^3/s to over 85 m^3/s. However, air flow rates were mostly below 50 m^3/s.

Underground barometric pressure remained within the range 105 to 110 kPa, but was usually 106 to 108 kPa (see Figure 15).

2. RADON GAS AND RADON PROGENY MEASUREMENTS

Data for a number of underground locations are given in Tables 3 and 4. Shown in the tables are the average values for [^{222}Rn], WL(Rn), WL(Tn), and their corresponding standard deviations. Also shown are average values for the F-factor, the ratio WL(Tn)/WL(Rn), and underground mining activities at each mine location. The basic difference between Tables 3 and 4 is that data in Table 4 is organized according to mining activity for each mine location, whereas the data in Table 3 are listed according to the time (i.e., date) at which data were collected at each location.

Radon gas concentration, [^{222}Rn], and radon progeny Working Level, WL(Rn), measurements for a few specific mine locations of interest are presented in Figures 16 to 27. These locations were chosen because of the bulk of data available which make them particularly suitable for graphical presentation. It should be noted that the histograms shown in the above Figures are presented in terms of number of occurrences, i.e., number of measurements, rather than the normalized number of occurrences or events as in Figures 6 to 15. The locations selected for the purpose of illustration are the following:

98100 - Footwall drive (heading and waste operations)

52984 - Jumbo development heading (also travelway)

52954 - Travelway (also jumbo development heading)

47K - Ramp in waste

38952 - Exhaust airway

26680 - Airway.

As Tables 3 and 4, and to some extent Figures 16 to 27 indicate, the average values for [^{222}Rn], WL(Rn), and the F-factor depend on the mine location and mining activity. As expected, the highest average values for [^{222}Rn] and WL(Rn) were found for exhaust airways such as 38952 and 45983, and locations where leaching operations were conducted such as 40143, 40144 and 43951. The lowest values for the above variables were found (also as anticipated) in airways such as 26680, 49683 and 59882. Other locations had intermediate values between air exhaustways, leaching operations and airways.

For air exhaustways, values for [^{222}Rn], WL(Rn), and F were up to, respectively, 200 pCi/L (7400 Bq/m^3), ~2, and ~0.8. For leaching locations, values in excess of 2 x 10^3 pCi/L (7.4 x 10^4 Bq/m^3), 10 WL(Rn), and F~0.8 were found. The above are, however, extreme and localized values. Average conditions for all underground locations combined are better represented in Figures 6 to 8.

It should be emphasized that the relationship between radiation variables such as [^{222}Rn], WL(Rn), WL(Tn), WL(Tn)/WL(Rn), and F and mining activity is not a straightforward one as air flow conditions play a very important role. This topic will be discussed in more detail in a separate section.

3. THORON GAS AND THORON PROGENY MEASUREMENTS

Tables 3 and 4 present data on WL(Tn) and the ratio WL(Tn)/WL(Rn). The average values for these two variables are tabulated along with the mining activity for a number of underground locations. The basic differences between Tables 3 and 4 have been noted above. Additional WL(Tn)

distributions (histograms) for several locations of interest are presented in Figures 28 to 33. Average WL(Tn) and WL(Tn)/WL(Rn) distributions for all underground locations combined are shown in Figure 10. Figure 9 shows a theoretically calculated [^{220}Rn] distribution based on direct experimental values of WL(Tn). The values for [^{220}Rn] were estimated as indicated in he section "Theoretical Background" (see also below).

As for the case of radon and its progeny, the highest values measured for WL(Tn) were at exhaust airways (e.g., 38952 and 45983) and leaching areas such as 43951 (see Tables 3 and 4 and Figure 32). Location 98100 (footwall drive, heading and waste operations) also showed significant WL(Tn) levels. Again, the lowest values for WL(Tn) were found in fresh airways such as 26680, 49683 and 59882, which also were the locations with the highest ratio WL(Tn)/WL(Rn). The highest values for WL(Tn) were in the range 0.6 to 0.7 (see Figures 10, 28 and 32), whereas the lowest were below 0.02 (see for instance Figures 31 and 33).

Direct thoron gas concentration, [^{220}Rn], measurements were conducted at several mine stations using the two filter tube (2FT) method (5). Concurrent measurements of WL(Tn) were also made. To the knowledge of the author, these represent the first direct measurements of thoron gas concentration in underground uranium mines in Canada. Table 5 shows [^{220}Rn] and parallel measurements of WL(Tn) for several sampling stations at two mine locations, namely, an exhaust airway (38952), and a travelway (52984). Also shown in Table 5 are air flow measurements. Although [^{220}Rn] and WL(Tn) are inversely related to airflow, Q, it is clear from Table 5 that the values for the above radiation variables at the exhaust airway are still substantially higher than for the travelway.

Data from Table 5 were also collected in order to investigate whether a value for the ratio WL(Tn)/[^{220}Rn] could be obtained that was sufficiently

reliable (i.e., constant) for practical applications. This ratio could then be applied to calculate [^{220}Rn] from measurements of WL(Tn). The values of [^{220}Rn] so obtained could then also be used to calculate thoron gas flux by the 2PM method, as indicated in the section "Theoretical Background" and in the section "Flux Measurements" (see below). It should be noted that the values for [^{220}Rn] shown in the histogram of Figure 9 were obtained using this ratio. Although the range of values calculated for [^{220}Rn] extended well beyond 200 pCi/L (7.4 x 10^3 Bq/m^3), only values in the range 0 to 100 pCi/L (0 to 3.7 x 10^3 Bq/m^3) are shown in the above histogram.

4. RADON GAS AND THORON GAS FLUX MEASUREMENTS

As previously discussed, flux measurements can be made using the 2PM method and the fluxmeter can method. Radon flux measurements were made using both methodologies whereas thoron flux determinations were made by the 2PM method only. Radon and thoron flux determined by the latter technique made use of several mine models such as the Thomas-Epps mine model (TEMM), a modified version of this model applicable to thoron gas, namely MTEMM, and two versions of the mine tunnel model with ventilation (MTMV). Because of the complexity of the subject, radon gas flux measurements and thoron gas flux measurements will be presented and discussed separately.

Radon Gas Flux Measurements

Radon gas flux from mine walls was determined by the fluxmeter can method at two selected mine locations. These were the same locations chosen for the concurrent measurements of [^{220}Rn] and WL(Tn) indicated above, namely, the exhaust airway 38952 and the travelway 52984.

A total of 12 fluxmeter cans was used. Six cans were placed at each mine location. The cans were installed at different positions along the mine walls of each location in order to obtain a representative sample

range. Flux measurements extended over a period of several months.

The fluxmeter cans were ~0.22 m in height and had a volume of 9.55 x 10^{-3} m^3. Taking into account that $\lambda(^{222}Rn) = 2.09 \times 10^{-6}$ s^{-1}, Equation 5 gives:

$$J \sim 4.53 \times 10^{-7} C(t_\infty) \quad pCi\ m^{-2}\ s^{-1},$$

this expression has been used here in the calculation of the radon flux (see Table 6). However, it should be emphasized that the values so obtained represent lower limiting values only because the proportionality factor α in Equation 6 has been set to zero. Hence, $\beta = \lambda$, and Equation 7 becomes Equation 5. In short, the condition $\alpha = 0$ indicates that J is independent of radon gas concentration gradients between interstitial pore volume below the rock surface and the fluxmeter can volume. Because $\alpha > 0$, $\beta = (\alpha/h) + h$ (in Equation 7) is greater than λ (in Equation 5), and the real values of J are greater than those given in Table 6.

The proportionality constant α, and hence β, depends on the radon gas emitting material, and can only be obtained by direct experiment in each case. The parameter β can be determined experimentally by following the growth of radon gas concentration in the fluxmeter can during the linear in-growth period (4). For a low permeability, low porosity material such as the rock formation in the present mine, the above procedure is long, time consuming and delicate, and it is best accomplished by automated continuous radon gas monitoring in the fluxmeter can volume. Because of practical constraints and considerations, the parameter β could not be determined accurately at the time of writing this report. From previous experiments at tailings sites for which β was calculated as ~5.2×10^{-5} s^{-1} (4), it is estimated that the value for hard rock should be in the range 2.1×10^{-6} $s^{-1} < \beta < 5.2 \times 10^{-5}$ s^{-1}.

Accurate values for β will soon be forthcoming and the revised values

for J in Table 6 will be given as well as details on the methodology used.

According to Table 6, the maximum radon flux measured at location 52984 was ~2.8 pCi m^{-2} s^{-1} (~0.1 Bqm^{-2} s^{-1}). This value is much lower than most values calculated for the same location using the Thomas-Epps mine model (TEMM) and the 2PM method (see below). The flux obtained for the other location (38952) was even lower by an order of magnitude. These discrepancies can be partly attributed to the uncertainty in the value for β, gas leakage from fluxmeter cans, radon gas dissolved in water percolating the mine walls, and the fact that the 2PM method (regardless of the mine model used) provides 'apparent flux' only and not true mine wall flux, as previously discussed.

Radon flux data by the 2PM method using the TEMM are given in Table 7. A summary of data for three specific locations of interest, namely 38952, 52984, and 47K ramp is given in Table 8.

Inspection of Tables 7 and 8 shows great discrepancies in the radon flux measured at different times (i.e., dates) during the underground monitoring program. These large differences in flux were observed when repeated measurements were made within a given general underground mine location using different pairs of sampling stations as well as when the same pairs of stations were used for sampling purposes.

Discrepancies in the first case, namely, when different pairs of stations are chosen for flux determination within a given location, can be partly understood because of the following:

a) defects in the rock formation such as cracks and faults;

b) water percolating through mine walls;

c) accumulation of ground water or mine water from the water supply which dissolves radon gas;

d) presence of some mining activity such as leaching, slushing, mucking

and rock breaking, and ore transportation operations;

e) change in ore grade;

f) change in the air flow conditions;

g) different mine section lengths for different pairs of stations; and

h) passing vehicles.

One, more than one, or all of the above items could conceivably be different for different pairs of stations and this might explain the discrepancies observed. More difficult to explain, however, is the case when repeated flux measurements were always conducted between the same pair of stations. In this case items a), b), e,) g), and in most cases item c), can be considered, or are, constant. This leaves items d), f) and b) as the only variables left. It is not difficult to see, however, that in many cases these items (except perhaps for item h) were noted as the same.

Table 7 shows that, in about 16% of the cases, negative values for the radon flux, J, were obtained. This percentage is significantly higher than one would expect on the basis of measurement errors and poor counting statistics. It is believed that at least in a number of cases, the negative values found are indeed 'real' values. This anomalous situation can argueably arise by the presence of:

1. 'Sinks' of radon gas between sampling stations, i.e., mine sites where radon gas can be absorbed, adsorbed, dissolved or removed by whatever means such as absorption in water and subsequent drainage, and by removal by air leakage.
2. Discrete, localized sources of radon at the first sampling station which does not contribute equally to the second station. This may include mining operations (item d) and defects in the rock formation (item a)).

Negative fluxes can also arise from a combination of items 1) and 2), and by a sudden decrease in ore grade from the first to the second sampling

station. In all cases, the negative values arise because the radon gas concentration at the second station (down stream) is lower than that of the first station. Airflow reversals, or rapid air changes during radon gas measurement, could also be responsible for 'anomalous' flux values.

Close to zero values and negative values for J could also occur under the following circumstances:

i) when the radon gas concentrations at both sampling stations are very similar; and

ii) when radon gas concentrations at both sampling stations are low, and hence statistics of counting is rather poor.

Item i) may occur when the distance between the two sampling stations is either too long or too short, as may be inferred from discussions elsewhere (14).

As expected, no difference in the J values was found when calculated according to models TEMM and MTEMM. However, significant differences were found when compared with predictions using the model MTMV (see Equations 15 and 16). Surprisingly enough, use of Equation 15 removed the negative values. A sample of these calculations is shown in the Appendix (see Tables A1 and A2). A detailed analysis of this topic and a comparison of the different models will be deferred to a forthcoming report.

Thoron Gas Flux Measurements

Experimental thoron gas flux measurements by the 2PM method conducted in an exhaust airway (38952), and a travelway (52984). For other locations, thoron flux was calculated from theoretical values for [^{220}Rn]. The reasons for this methodology have been discussed in the section "Theoretical Background". The locations above were selected to derive experimental values for this ratio. The latter was found to be in the range 1.1×10^{-3} - 3.6×10^{-3} WL/pCi^{-1}, depending on airflow conditions and other considerations. The

concurrent measurements of $[^{220}Rn]$ and WL(Tn) shown in Table 5 were used to calculate the ratio $WL(Tn)/[^{220}Rn]$. The average value for the latter was very close to 2×10^{-3} $WL/pCiL^{-1}$. About 50% of the total number of measurements made gave values close to this figure. Hence, the following expression was adopted for the calculation of thoron gas concentration:

$$[^{220}Rn] = 5 \times 10^{2} \, WL(Tn) \qquad \text{Eq 25}$$

As for the radon flux case, thoron flux by the 2PM method was determined using the mine models TEMM, MTEMM, and two versions of the MTMV. The TEMM gives erroneous results for the thoron flux, $J(^{220}Rn)$, because the model does not make provisions to account for the radioactive decay of ^{220}Rn during the transit time between sampling stations or travel time in general. Predictions made by the other three models differed significantly from each other.

Table 9 shows data obtained using the four mine models for three locations. Data for location 47K was calculated using Equation 25. Tables A3, A4, A5 and A6 in the Appendix give samples of data obtained from other locations.

Except for the model MTMV (Equation 15), the other models give negative values for $J(^{220}Rn)$ occasionally. The same reasons given for the radon flux, $J(^{222}Rn)$, to explain these results could be applied to the thoron case. The reader should be aware, however, that because of the short half-life of ^{220}Rn (~55 s), the distance chosen between sampling stations might become critical in order to obtain meaningful results. Only under high airflow conditions, and hence, low mine air residence times, does distance between sampling stations become less critical. This and other issues will be discussed in detail in a forthcoming report.

The thoron flux to radon flux ratio, i.e., $J(^{220}Rn)/J(^{222}Rn)$ is of great theoretical interest as well as practical interest. Table 10 shows

$J(^{220}Rn)$ and $J(^{222}Rn)$ for several underground locations with different mine air residence times. The data were obtained with the model MTMV as described by Equation 15. Further information on the flux ratio can be obtained by comparing Tables 8 and 9, and A1 and A2 with A3 to A6.

Examination of the data shows no clear relationship between the flux ratio and mine air residence time. However, the Tables show striking results, namely, the flux ratios are considerably lower than theoretically anticipated. For a gram ratio $^{238}U/^{232}Th$ of unity, the expected theoretical flux ratio at the mine wall/air interface is about 240 (14). For higher or lower gram ratios the above figure would be correspondingly higher or lower, respectively. The relationship between flux ratio and gram ratio is a linear one.

No satisfactory explanation can be offered at present regarding the discrepancy between theoretical and experimental values for the flux ratio, except noticing the 'apparent' nature of the fluxes determined by the 2PM method as opposed to mine wall/interface fluxes determined by fluxmeter cans. Apparent fluxes are affected by a variety of factors, as previously discussed. These factors may affect the evaluation of radon and thoron fluxes differently. Finally, the reader is reminded that the theoretical flux ratio indicated above refers to mine wall/air interfaces, and strictly speaking, should therefore, not be applied to or compared with, apparent fluxes and apparent flux ratios.

5. SEASONAL VARIATIONS OF THE RADIATION AND METEOROLOGICAL UNDERGROUND ENVIRONMENTS - THEIR RELATIONSHIP

The radiation environment in underground (uranium) mines can be highly variable. Some variations in airborne radioactivity are brought about by mining operations and other mine activities, as well as by varying airflow

conditions.

The climatic and meteorological environments in Canada change considerably over the yearly seasons. These changing conditions affect, to a large extent, the meteorological and climatic conditions in underground mines such as temperature (T), barometric pressure (P), relative humidity (RH), aerosol concentration (N), and natural airflow conditions. Underground meteorological and climatic variations can, in turn, affect radon emanation from mine walls, and hence, radon and radon progeny concentrations in mine air, whereas aerosol concentration is known to affect plate-out of radon progeny on large mine surfaces such as walls. The same arguments can be applied to thoron and its progeny.

Seasonal variations can be best investigated by selecting a number of underground locations and looking for:

a) seasonal changes in meteorological variables;

b) seasonal changes in radiation variables; and

c) relationships between radiation and meteorological variables.

Selection or choice of 'relevant' variables can be made based on theoretical grounds and speculation, and on previous experience as starting points. The only variables that should be considered are those determined experimentally. In the context of this work, these would include [^{222}Rn], J(^{222}Rn), WL(Rn) and WL(Tn) for the radiation variables, and T, RH, P, and Q for the climatic and meteorological variables. However, as airflow, Q, is not affected by external conditions, but is rather established to control underground radiation and climatic conditions, it should not be included in the analysis and discussion. (It should be noted that Q is precisely the variable that can affect, most effectively, underground radiation levels.) Aerosol concentration was not measured, and hence, is not included in the analysis.

Barometric pressure changes are the only likely candidate to affect radon emanation from walls, i.e., J(^{222}Rn). However, the maximum barometric pressure variation during the monitoring program was about 5 kPa, a pressure change which is not considered sufficient to greatly affect J(^{222}Rn) in low permeability/low porosity materials except at fractures and faults.

In order to investigate the effect of underground meteorological and climatic conditions on the radiation environment, each radiation variable of interest (i.e., [^{222}Rn], J(^{222}Rn), WL(Rn) and WL(Tn)) was 'correlated', in turn, with each of the following variables, T, RH, P, ..., separately. Multivariate analysis was not considered necessary because of the results obtained in the individual correlations.

Pairs of variables were analyzed using a special computer program (CURVE.FIT) which produced 'best' fits by the least squares analysis method. The program included a total of 22 different analytical functions such as linear, power, parabolic and exponential, to which each pair of variables was fitted.

Table 11 shows a summary of long-term radiation, meteorological and climatic conditions (daily averages) for four 'representative' underground locations. Also shown in the Table is the corresponding mining activity at the time of the measurements. Examination of Table 11 does not permit one to draw firm conclusions regarding seasonal variations of the above variables, except perhaps, for T and RH. This is partly so because airflow conditions and mining activity for each location did not remain constant throughout the monitoring program. In some cases, lack of sufficient data was a determinant factor.

Tables 12 to 16 show the fitting of experimental data to several analytical functions using CURVE.FIT. Horizontal bars indicate that the correlation coefficient (R^2) was less than 0.2. In a few cases it also means

program overflow.

The data of Tables 12 to 16 are not particularly suggestive. Poor correlation was found except for a few cases. The analytical functions which best fitted the experimental data do not seem to have a strong physical meaning.

From the data presented in this section, one may conclude that if there is any seasonal variation of airborne radioactivity or clear relationship between radiation and meteorological and climatic variables it has been masked by changes in airflow conditions and/or mining activity, the two most dominant factors.

6. RELATIONSHIP BETWEEN MINING ACTIVITIES AND RADIATION CONDITIONS

Table 3 shows daily averages for several radiation variables and ratios of interest for several underground locations, and their corresponding mining activity at the time of the measurements. Table 4 presents the average value for the above variables taken over all the days during which the same mining activity took place. Table 4 is more suitable to establish a relationship between airborne radioactivity and mining activities and operations. (the mining activity description based on the encoded numbers given is shown in Table 1.) Tables 3 and 4 were presented and discussed earlier in a different context. However, because of the dominant role that airflow conditions has on airborne radioactivity, Tables 3 and 4 are not especially suitable for the purposes of our discussion. Tables 17 and 4, when inspected concurrently, are most useful in studying the relationship between airborne radioactivity and mining operations.

Inspection of Tables 4 and 17 show that there were only a few underground locations for which changes in mining activity occurred while airflow conditions remained constant, or nearly constant. These locations are the

following: 38070 (Jackleg stope), 38954 (travelway), 38071 (Jackleg stope), 38062 (Jackleg stope), 45983 (exhaust airway), CR.dec. (Crusher decline), and 57852 (travelway).

Table 18 shows the effect of mining operations or activities on airborne radioactivity for the few underground locations for which airflow conditions remained constant throughout. In general, the main conclusions that can be drawn for this limited set of data is that an increase in airborne radioactivity was observed when:

1. traffic of vehicles and personnel occurred relative to non-traffic conditions;
2. any mining activity or operation was initiated relative to non-traffic, non-operation condition;
3. slushing operations took place relative to drilling operations.

Items 1 to 3 are not surprising and to be expected. The most consistent indicator of radioactivity changes brought about by mining operations and activities was radon gas concentration. WL(Rn) and WL(Tn) were not such good indicators because of the relatively low values for these values, and hence, poor statistics of counting.

7. PREDICTION OF RADIATION LEVELS BY VENT.RAD

VENT.RAD is a computer program developed by Queen's University (Dept. of Mining Engineering) (6), based on Schroeder and Evans radiation mine model (20). VENT.RAD has been designed to calculate [^{222}Rn] and WL(Rn) from radon gas flux (input) data. This model has been described briefly in a previous section (see Equations 17 to 24).

In order to test the predictive power of VENT.RAD a number of locations were selected for which radon flux data, and [^{222}Rn] and WL(Rn) data for different pairs of stations were available. The results of these

calculations are shown in Table 8. This Table shows data for the three locations 52984, 38952 and 47K ramp. Shown in the Table are the apparent flux, J, the initial and final conditions for [^{222}Rn] and WL(Rn), i.e., values for the first and second mine stations where measurements were made. Also shown in the Table are the calculated values for [^{222}Rn] and WL(Rn) using VENT.RAD. The calculations used J and a number of geometric and physical data not shown in this Table such as cross-sectional area and distance between stations.

Inspection of the data of Table 8 indicates that for relatively high radiation levels, theoretical and experimental data agreed well. However, for low radiation levels there was poor agreement between experimental and theoretical data for WL(Rn), although agreement was fairly good for [^{222}Rn], except for a few cases.

A detailed analysis of the reasons for the discrepancies observed is beyond the scope of this report. However, a few comments are in order:

1. Apparent radon fluxes are used as input data;
2. Mining operations and activities are difficult to quantify as radiation sources or radiation 'sinks';
3. No plate-out effects are taken into consideration in the program;
4. The radiation aspects of the mine model are simplistic in its basic assumptions, and hence, limited in scope;
5. Poor statistics of counting;
6. Lack of data regarding aerosol and airborne dust concentrtion that can affect radon progeny attachment; and
7. Time dependent perturbation terms are not considered in the radiation model.

The above are only a few comments. The need for designing and preparing careful experiments so that a mine model can be adequately tested,

namely, tested under favourable conditions, should be stressed. In other words, mine models should be tested only under conditions they can handle or deal with, and for which they have been designed.

It was previously indicated that VENT.RAD was not originally developed to deal with thoron and its progeny. One way to get around this is by using a relationship beween WL(Tn) and WL(Rn) based on experimentation which is accurate and representative enough for practical applications. However, this is contingent on the model being capable of predicting WL(Rn) with reasonable accuracy. This and other topics will be dealt with in a forthcoming report.

8. THE THORON PROBLEM AND OTHER PROBLEMS

Prediction of thoron and thoron progeny concentrations is a topic of practical interest in Canadian underground uranium mines. In reviewing this topic three items stand out, namely:

1. Lack of adequate research interest in developing realistic, and hence, theoretically complex radiation mine models capable of handling short-lived decay products, convective deposition of these radioisotopes on mine surfaces, and time-dependent situations of practical interest. Concurrent to this is the problem of developing sophisticated computer codes to solve, by numerical methods, sets of simultaneous kinetic differential equations describing the different processes and physical mechanisms of interaction of interest;
2. Experimental difficulties in determining the thoron flux, $J(^{220}Rn)$, a fundamental variable on which mine models are based; and
3. Difficulty in designing underground monitoring and testing programs to validate the model(s).

A great deal of effort has been made by the author regarding item 1) (14,17-19).

There are serious experimental problems associated with in situ determination of $J(^{220}Rn)$ in the presence of ^{222}Rn by the fluxmeter can method. A method has been developed by the Elliot Lake Laboratory based on α-spectrometry techniques that can solve this problem although serious experimental difficulties still persist.

Determination of $J(^{220}Rn)$ by the 2PM method requires special attention with regard to the distance chosen between successive sampling stations. Thoron gas concentration, $[^{220}Rn]$, on which $J(^{220}Rn)$ measurements are based, can be determined with relative ease by the 2FT method. This method is, however, delicate and time-consuming because of the presence of ^{222}Rn. An alternative method of great promise has been offered by the author (21). In this method activated carbon, C*, is used in conjunction with a high purity germanium detector (HPGD). Because of the high γ-energy resolution of the HPGD, discrimination of radon progeny and thoron progeny γ-emitting radioisotopes is possible, thereby enabling simultaneous determination of $[^{220}Rn]$ and $[^{222}Rn]$. Devices that can be used for the determination of both radioisotopes have been designed and calibrated at the Elliot Lake Laboratory.

Accurate measurement of $J(^{220}Rn)$ would permit validation of mine models as well as it would provide a test for the surprisingly low ratio $J(^{220}Rn)/J(^{222}Rn)$ found in this study. Perhaps it is superfluous to mention it, but the reader should be aware that without knowledge of $J(^{220}Rn)$ no validation of any mine model is possible. Any relationship between WL(Tn) and WL(Rn) used to derive WL(Tn) from the latter is purely an empirical one (see below), and any spatial or temporal dependence that can be derived for WL(Tn) or ^{212}Pb (ThB) relies ultimately on $J(^{220}Rn)$ for verification.

Finally, with regard to empirical modelling, it is of interest to mention for the sake of completeness that WL(Tn) and WL(Rn) data collected

during the underground monitoring program were analyzed using least square fitting techniques. Two analytical functions were investigated, namely, a linear and a power relationship. The result of this analysis is shown in Equations 26 and 27, and Figures 34 and 35:

$$WL(Tn) = 0.8778\ WL(Rn) + 0.0523,\ R^2 = 0.86 \qquad \text{Eq 26}$$

and,

$$WL(Tn) = 0.61\ (WL(Rn))^{0.605},\ R^2 = 0.68 \qquad \text{Eq 27}$$

where, R^2 is the correlation coefficient.

Equations 26 and 27 are not much different from similar analyses with other sets of data obtained in the past in other underground uranium mines in the Elliot Lake area. It has been found that the linear and power functions complement one another, i.e., each function fits the experimental data best within a particular range of values for WL(Rn).

The discussion in this section applies to some extent to radon as well as thoron. However, the reader should draw the parallel analogies whenever applicable.

MAIN CONCLUSIONS

In summary, the following may be concluded:

1. A wide range of radiation, meteorological, and climatic conditions were found underground.
2. An empirical relationship between WL(Tn) and WL(Rn) was obtained which might be of practical interest.
3. Thoron gas concentrations, [^{220}Rn], were measured at Denison Mines Ltd. for the first time using the 2FT method.
4. From concurrent measurements of [^{220}Rn] and WL(Tn), a relationship was derived to calculate thoron flux, J(^{220}Rn), from WL(Tn) measurements.
5. Radon flux measurements, J(^{222}Rn), determined by the fluxmeter can method were substantially lower than that obtained by the 2PM method.

Furthermore, negative values for $J(^{222}Rn)$ were obtained by the 2PM method when the mine model TEMM was used. Such a situation did not arise when the MTMV (Equation 15) was used.

6. The ratio $J(^{220}Rn)/J(^{222}Rn)$ was considerably lower than theoretically predicted .
7. No seasonal dependence for airborne radioactivity could be established, mainly because airflow conditions did not remain constant.
8. From the limited number of data sets available, a relationship between radiation levels and mining operations, and activities could be demonstrated.
9. $[^{222}Rn]$ and WL(Tn) predictions by VENT.RAD varied from good to poor depending on the radiation level. Comparison was based on $J(^{222}Rn)$ measurements by the 2PM method.

SUGGESTIONS FOR FUTURE WORK

In view of the results obtained in the course of this investigation the following are suggested for future work:

1. More accurate determination of $J(^{220}Rn)$ and $J(^{222}Rn)$ by new and/or improved methodologies.
2. Systematic determination of $[^{220}Rn]$ by means of the 2FT and C* methods.
3. Design of underground tests aimed at validating mine models with reliable values of J derived from item 1.
4. More emphasis in radiation mine modelling and its corresponding computer coding.

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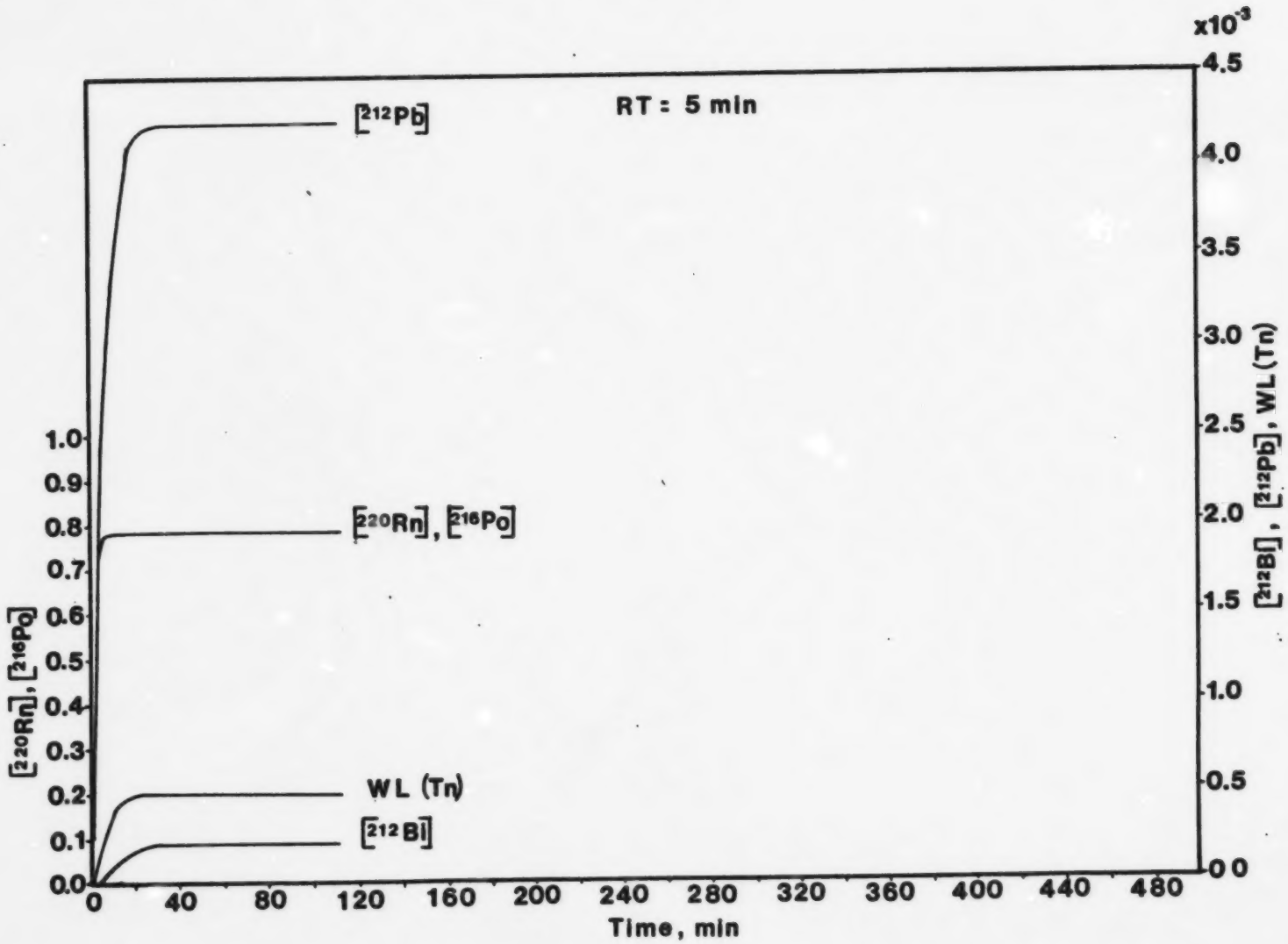

Fig. 1 - Thoron/thoron progeny concentration versus time calculated according to the MTMV for an air residence time RT = 5 min.

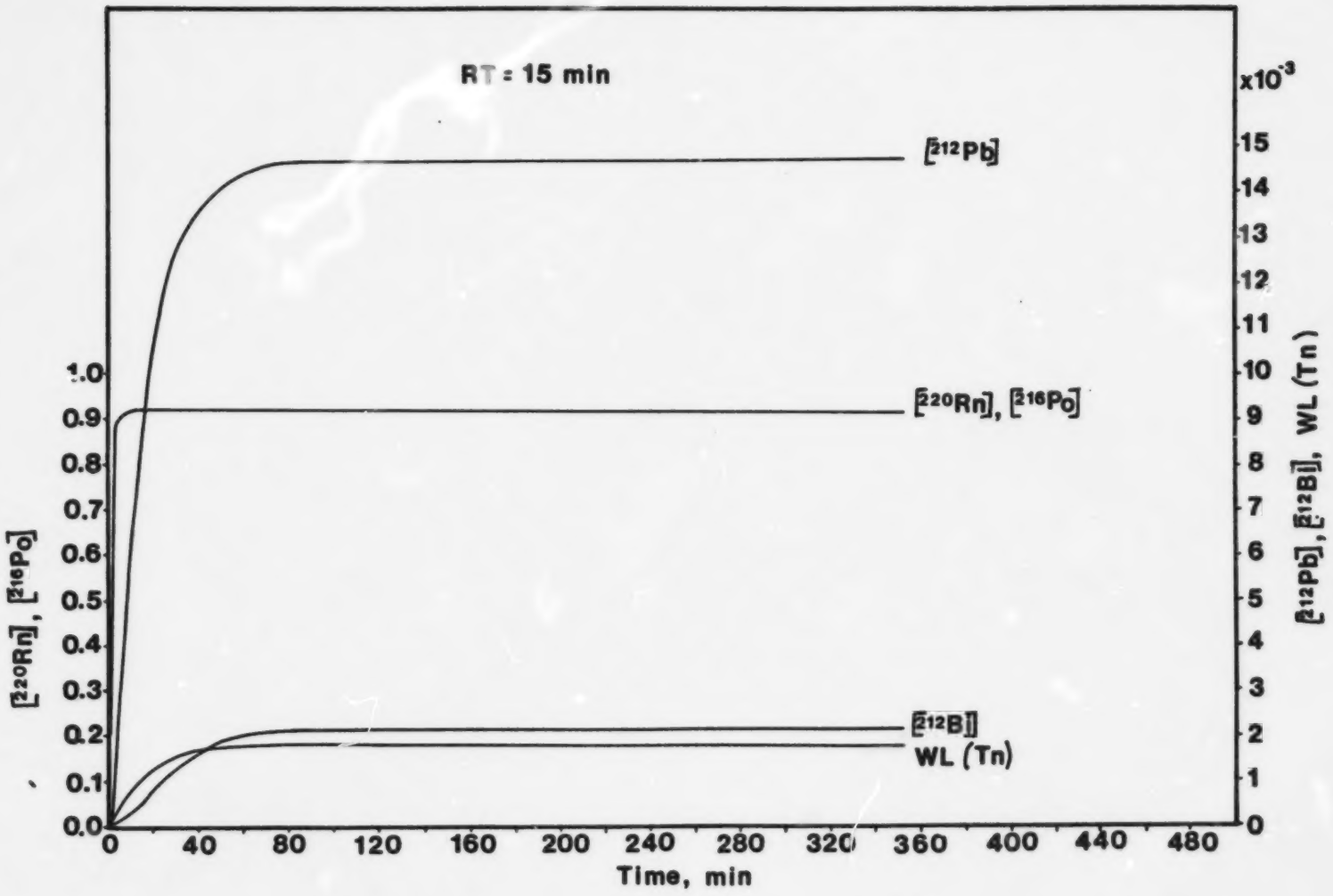

Fig. 2 - Thoron/thoron progeny concentration versus time calculated according to the MTMV for an air residence time RT = 15 min

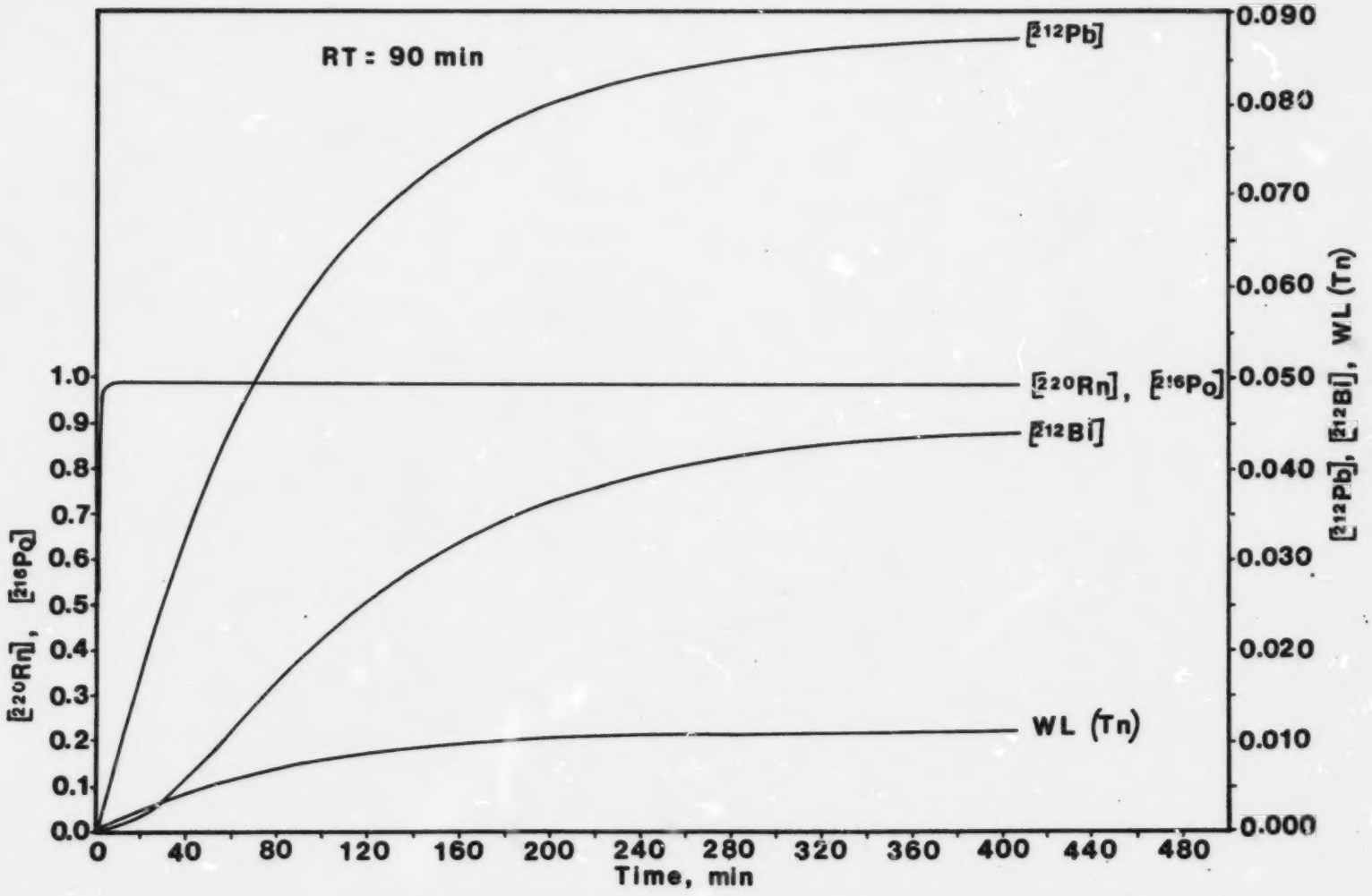

Fig. 3 - Thoron/thoron progeny concentration versus time calculated according to the MTMV for an air residence time RT = 90 min.

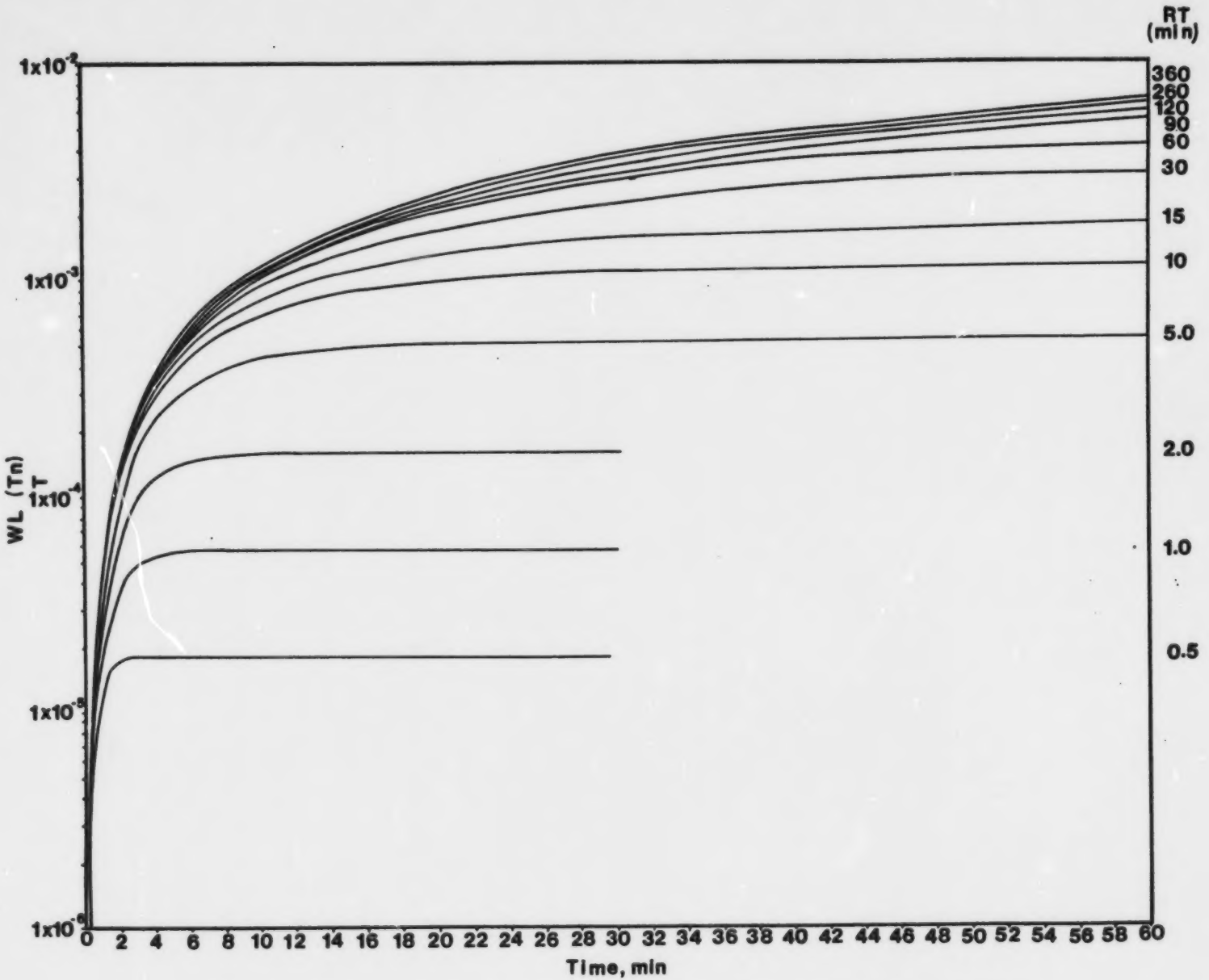

Fig. 4 - Thoron progeny Working Level versus time calculated according to the MTMV for several air residence times (RT).

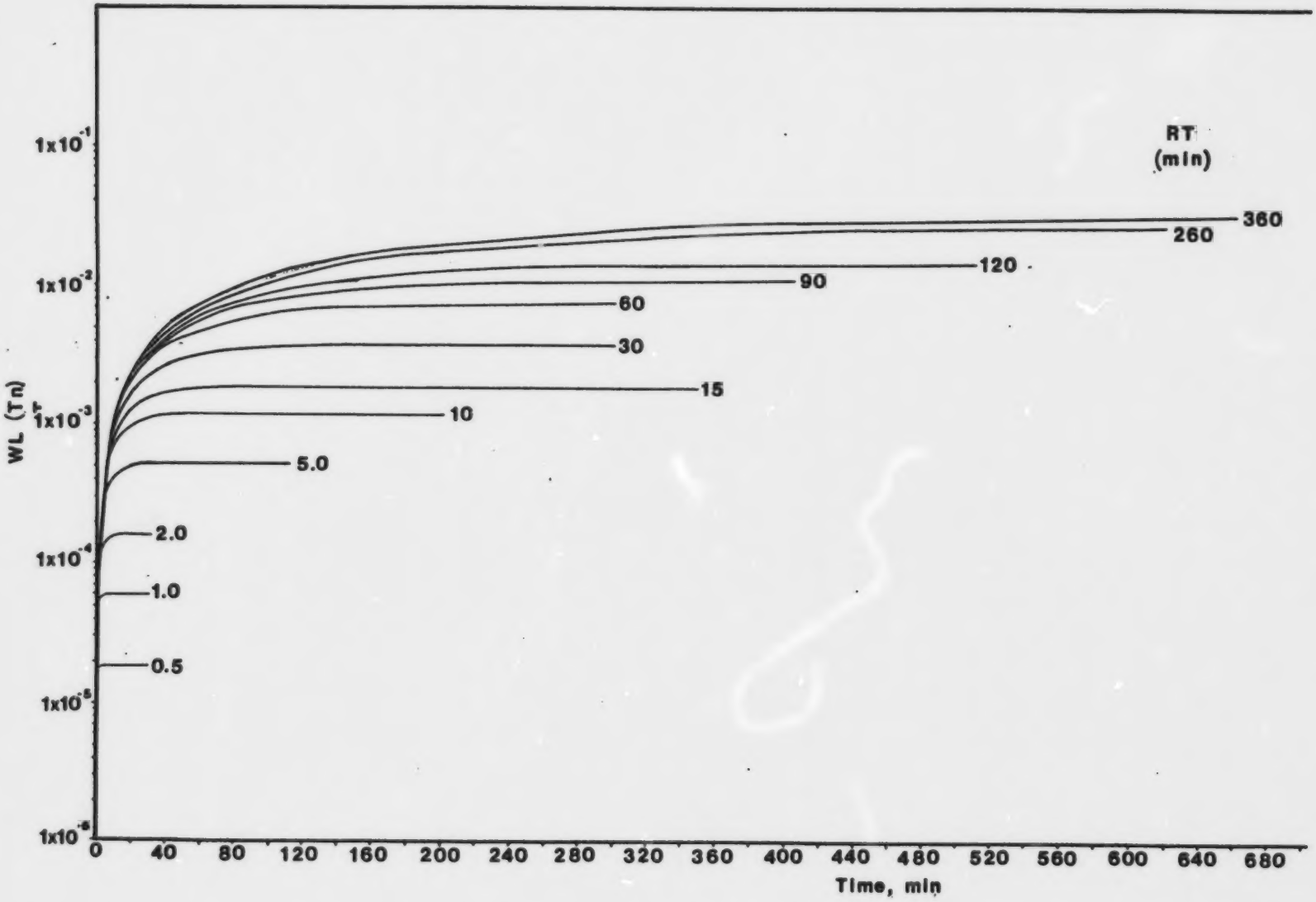

Fig 5 - Thoron progeny Working Level versus time calculated according to the MTMV for several air residence times (RT).

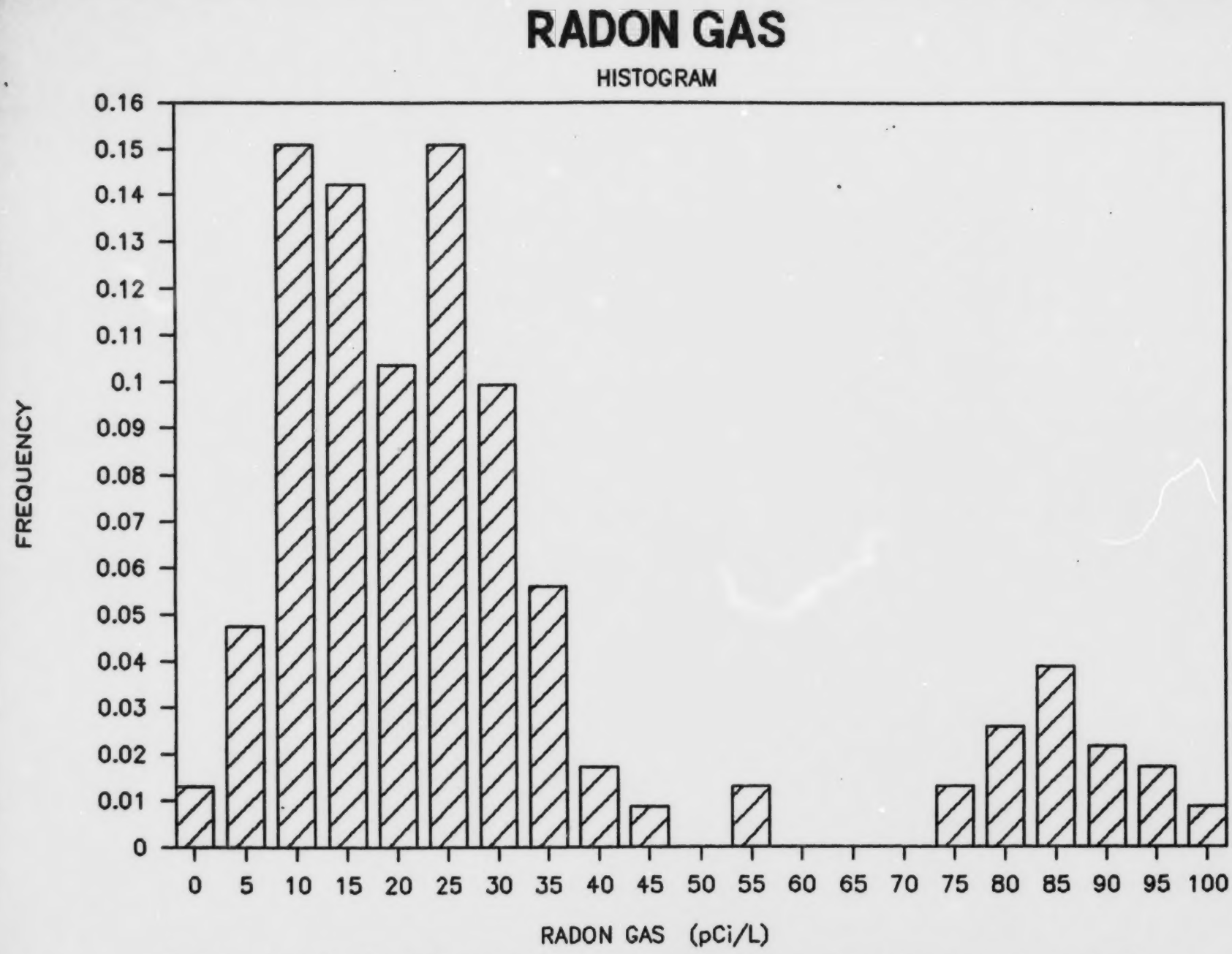

Fig. 6 - Normalized number of radon gas measurements (frequency) versus radon gas concentration for underground (U/G) samples taken during the field study.

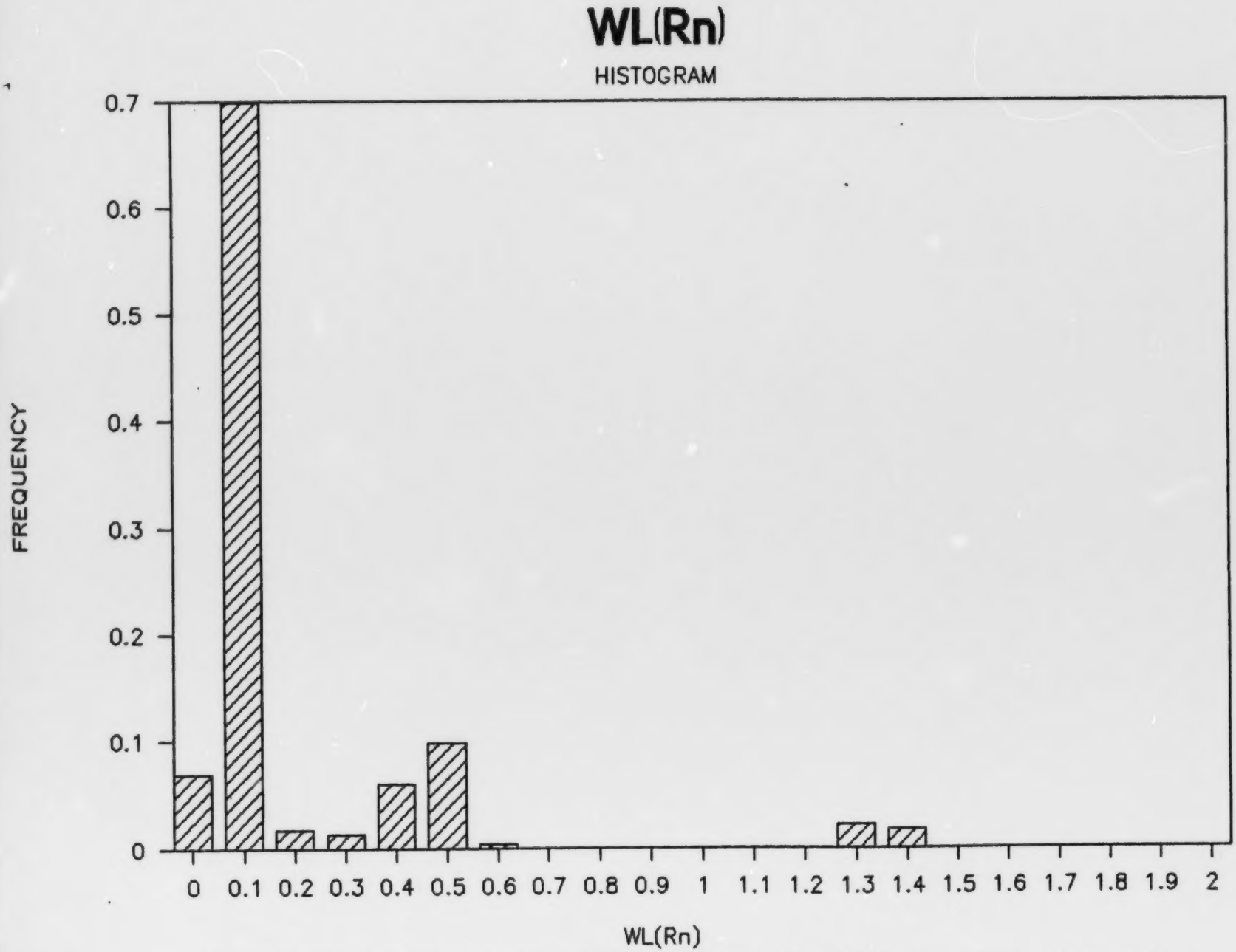

Fig. 7 - Normalized number of radon progeny Working Level, WL(Rn), measurements (frequency) versus WL(Rn) for U/G samples taken during the field study.

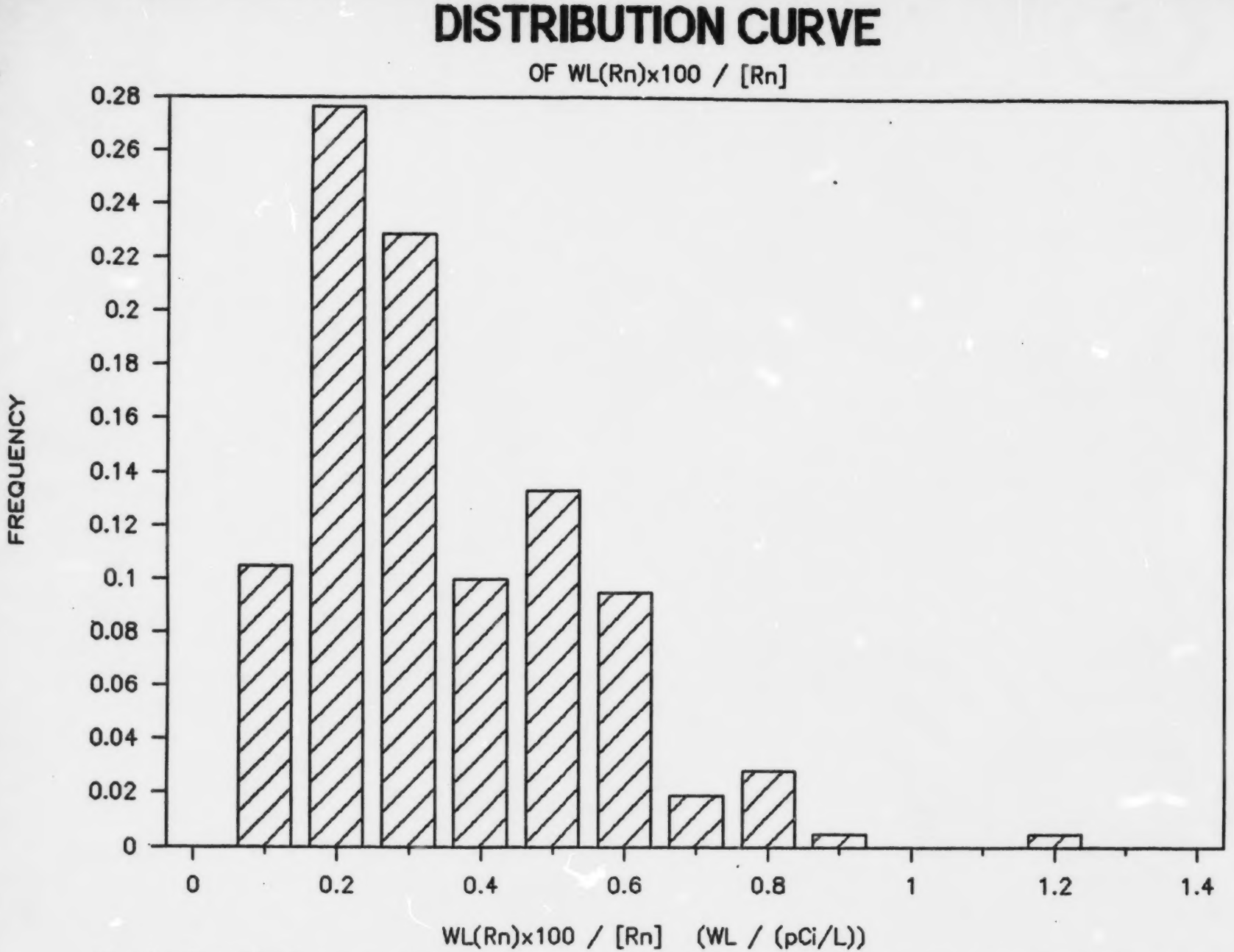

Fig. 8 - Normalized number of F-factor measurements (frequency) versus F for U/G samples taken during the field study. The F-factor is defined by the following relationship: $F = WL(Rn) \times 10^2/[^{222}Rn]$.

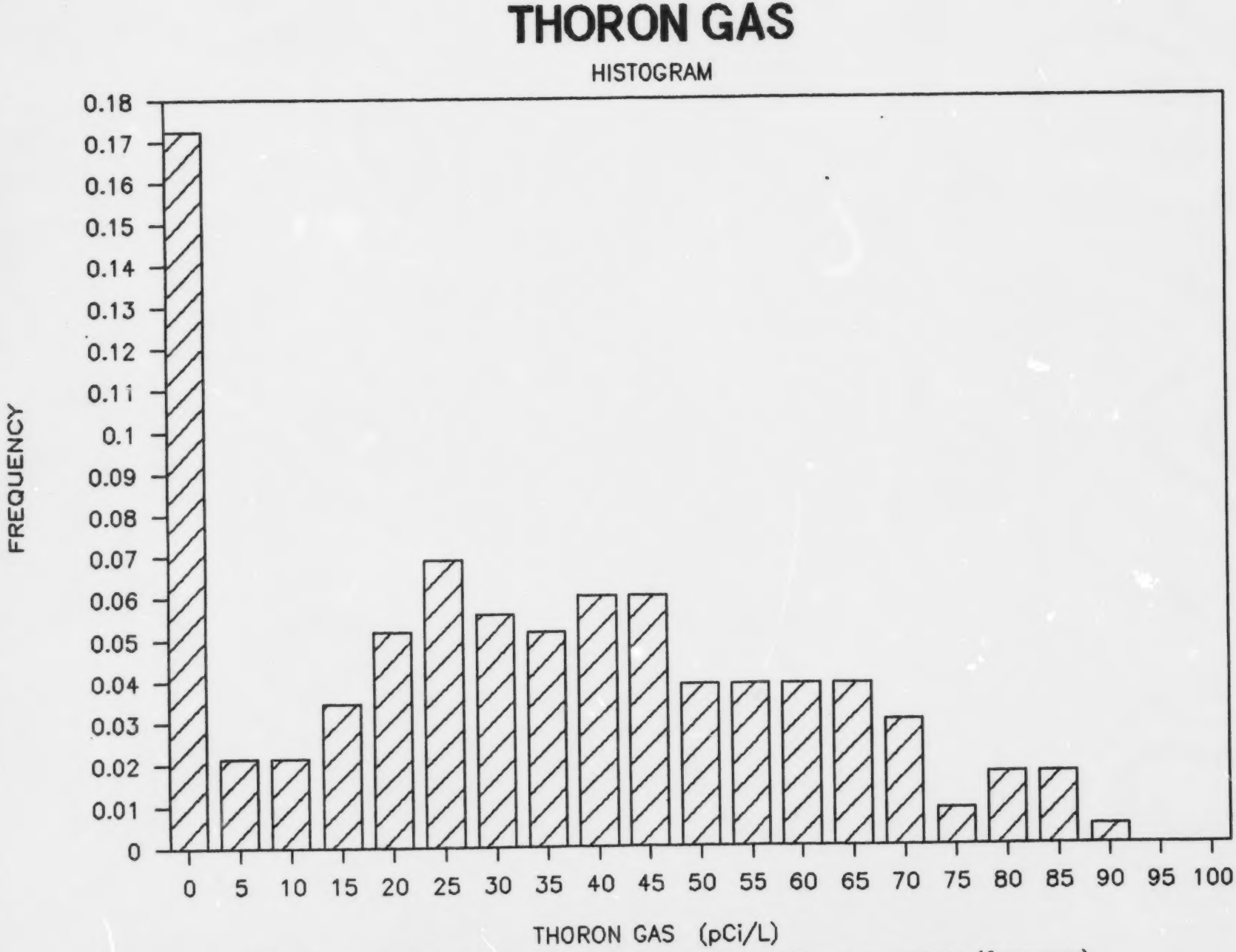

Fig. 9 - Normalized number of thoron gas concentration measurements (frequency) versus thoron gas concentration.

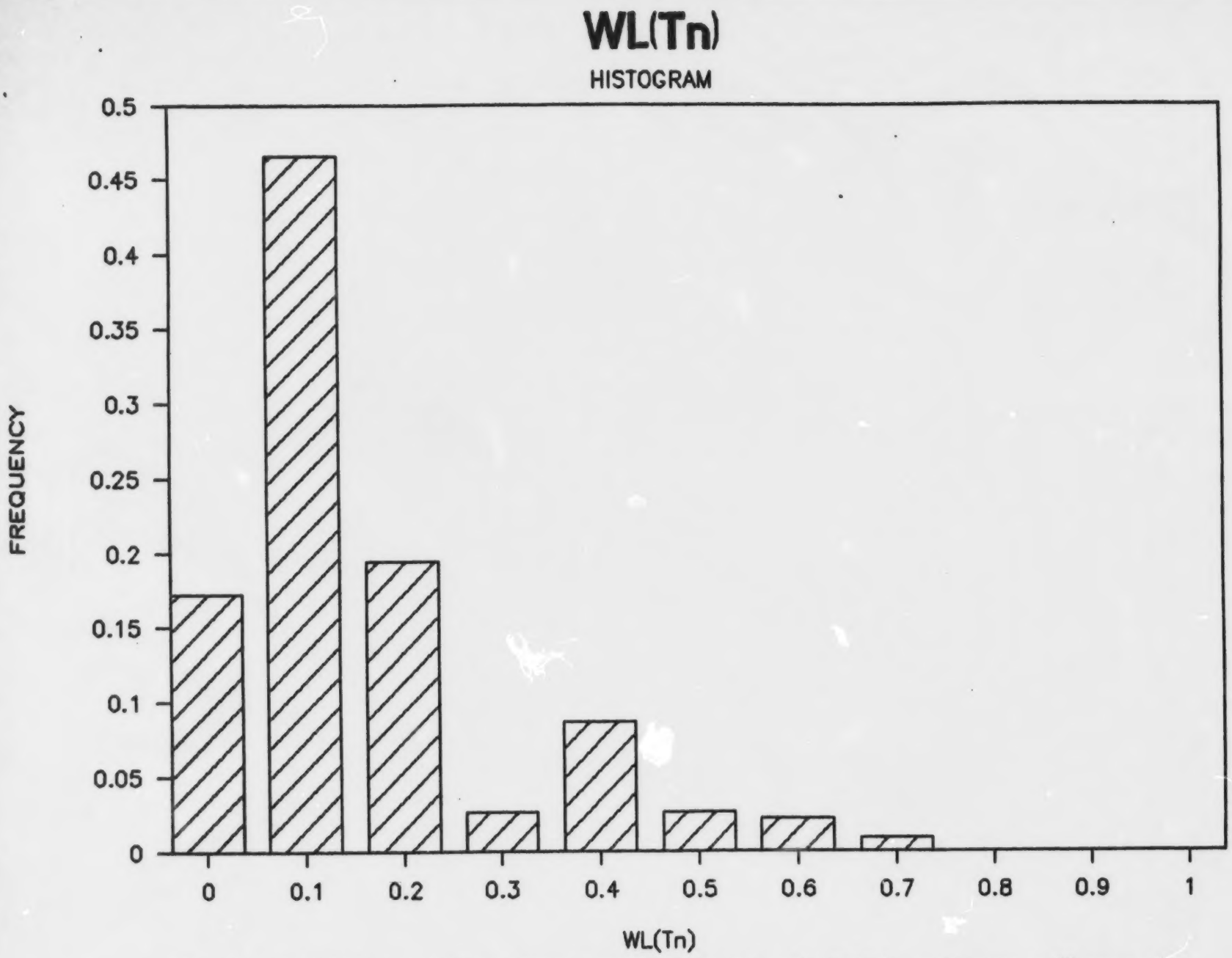

Fig. 10 - Normalized number of thoron progeny Working Level, WL(Tn), measurements (frequency) versus WL(Tn) for U/G samples taken during the field study.

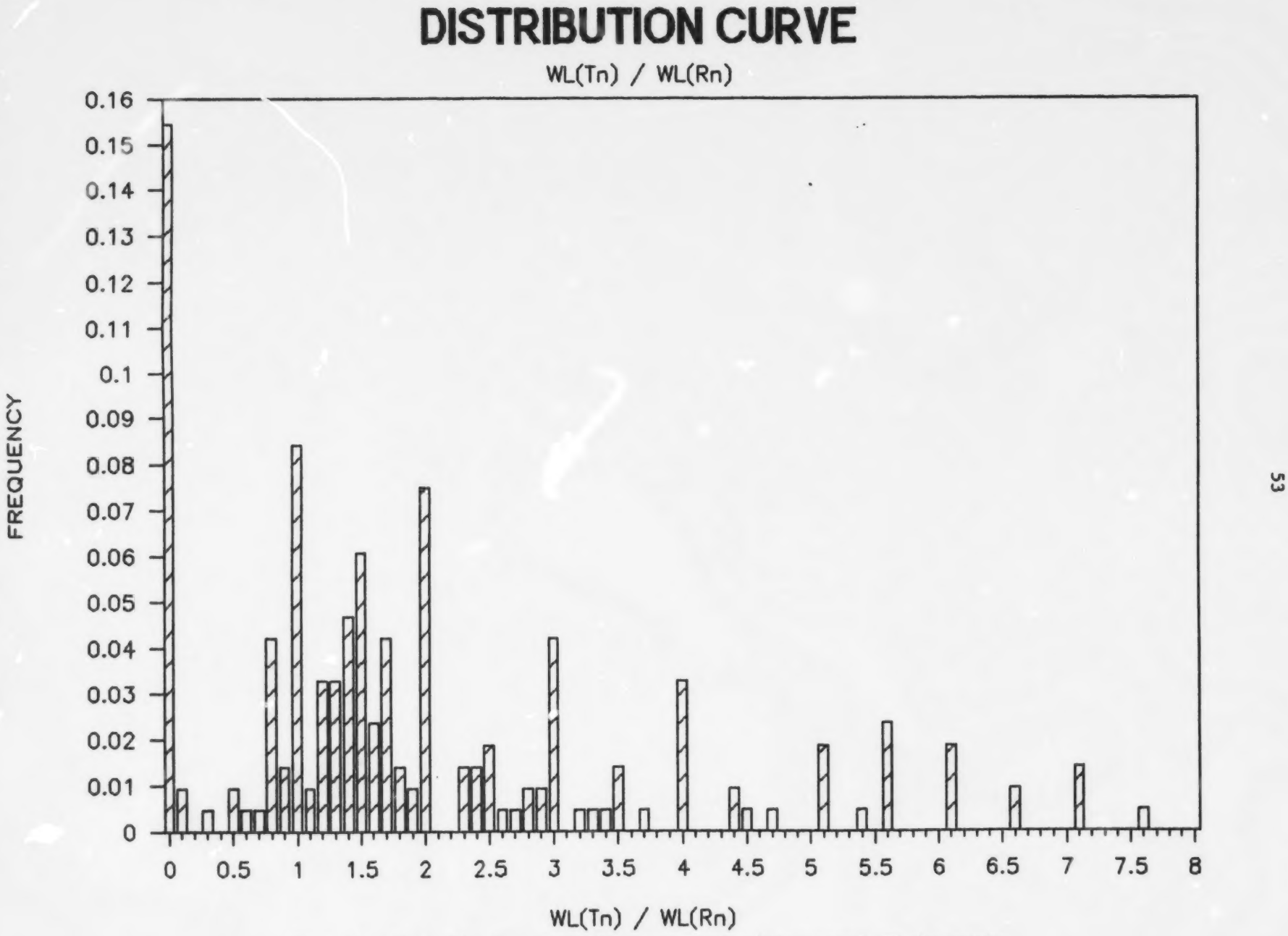

Fig. 11 - Normalized number of measurements (frequency) of the ratio WL(Tn)/WL(Rn) versus this ratio.

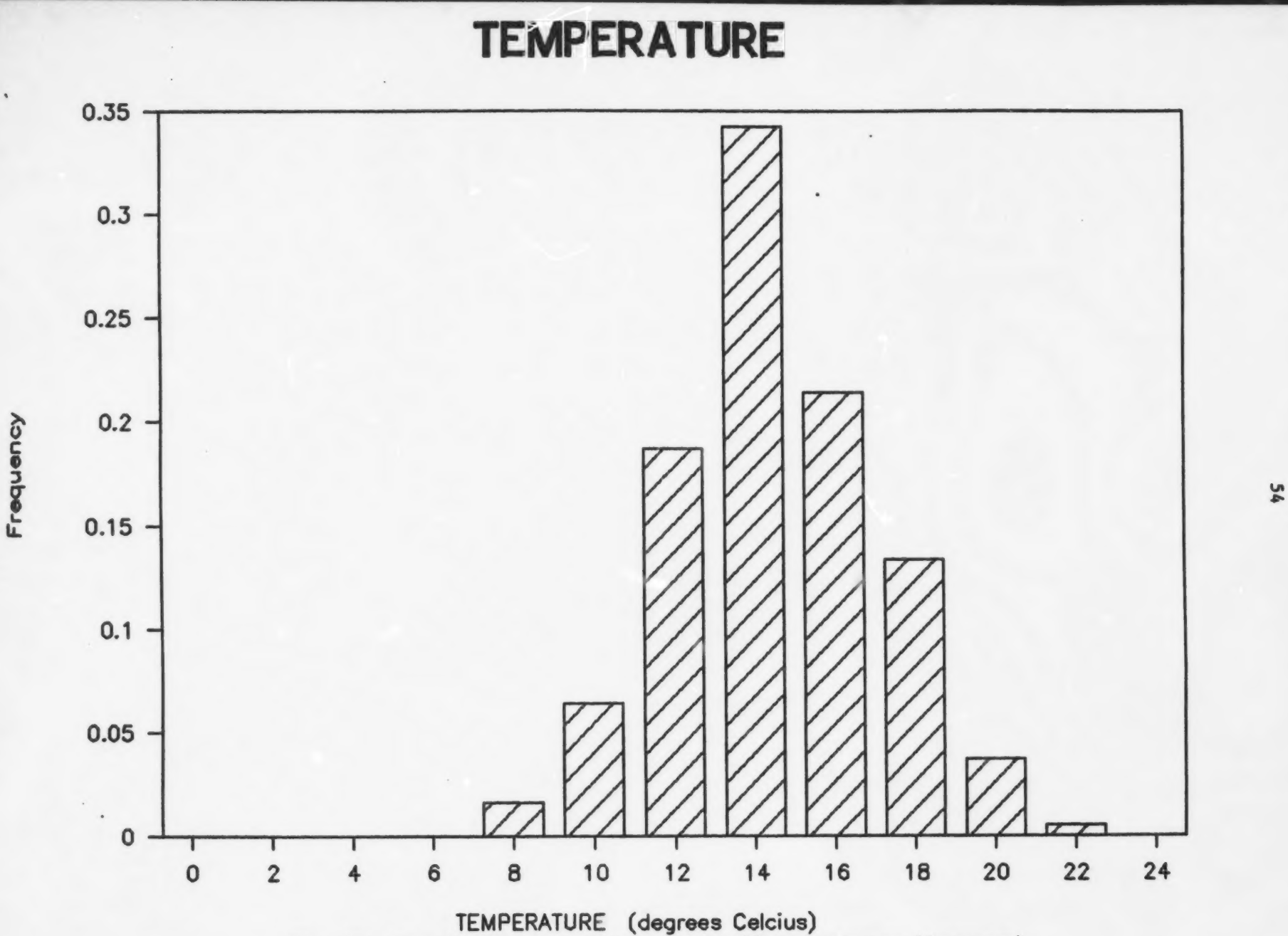

Fig. 12 - Normalized number of temperature (T) measurements (frequency) versus T taken at different U/G locations.

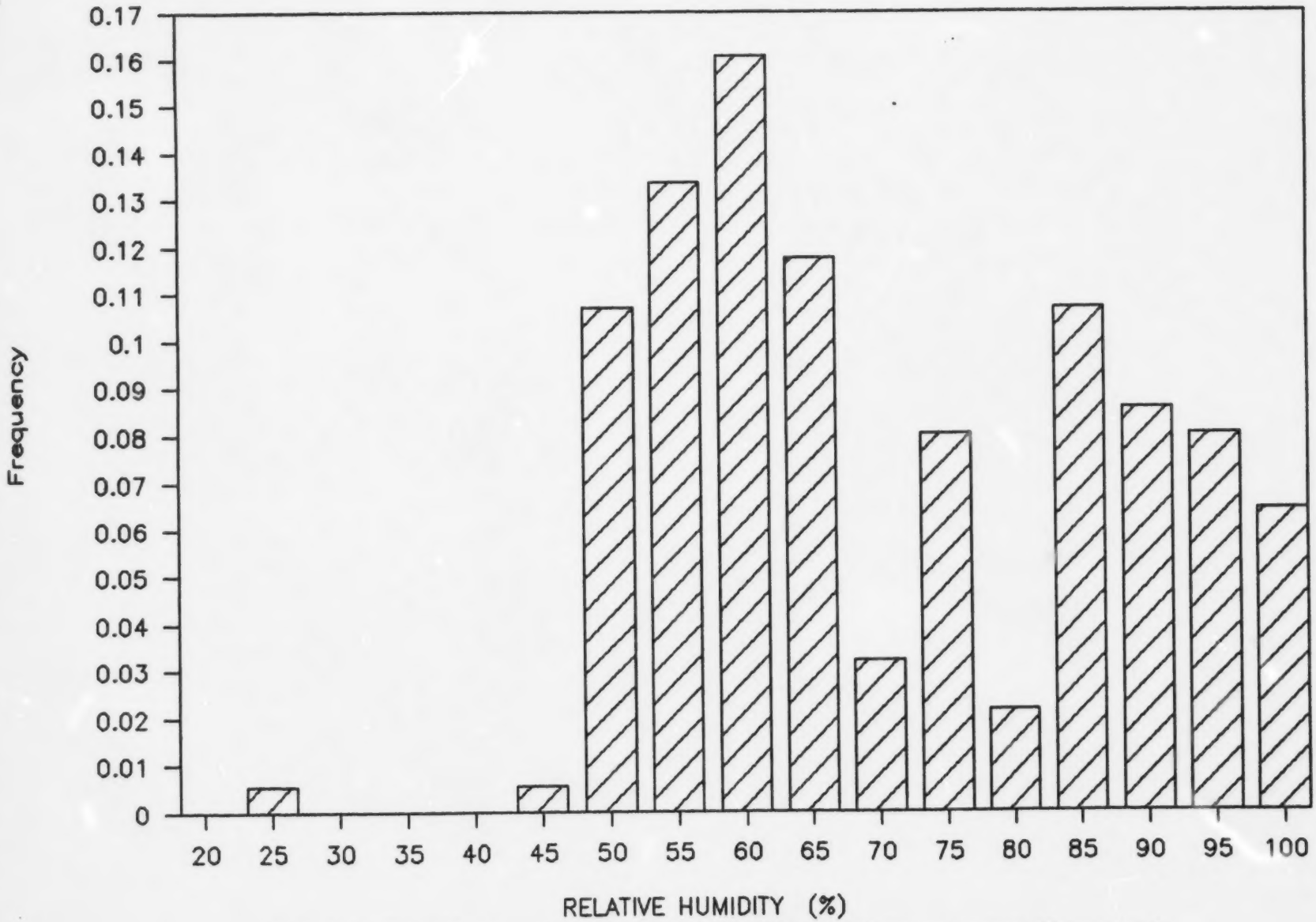

Fig. 13 - Normalized number of relative humidity (RH) measurements (frequency) versus RH (%) taken at different U/G locations.

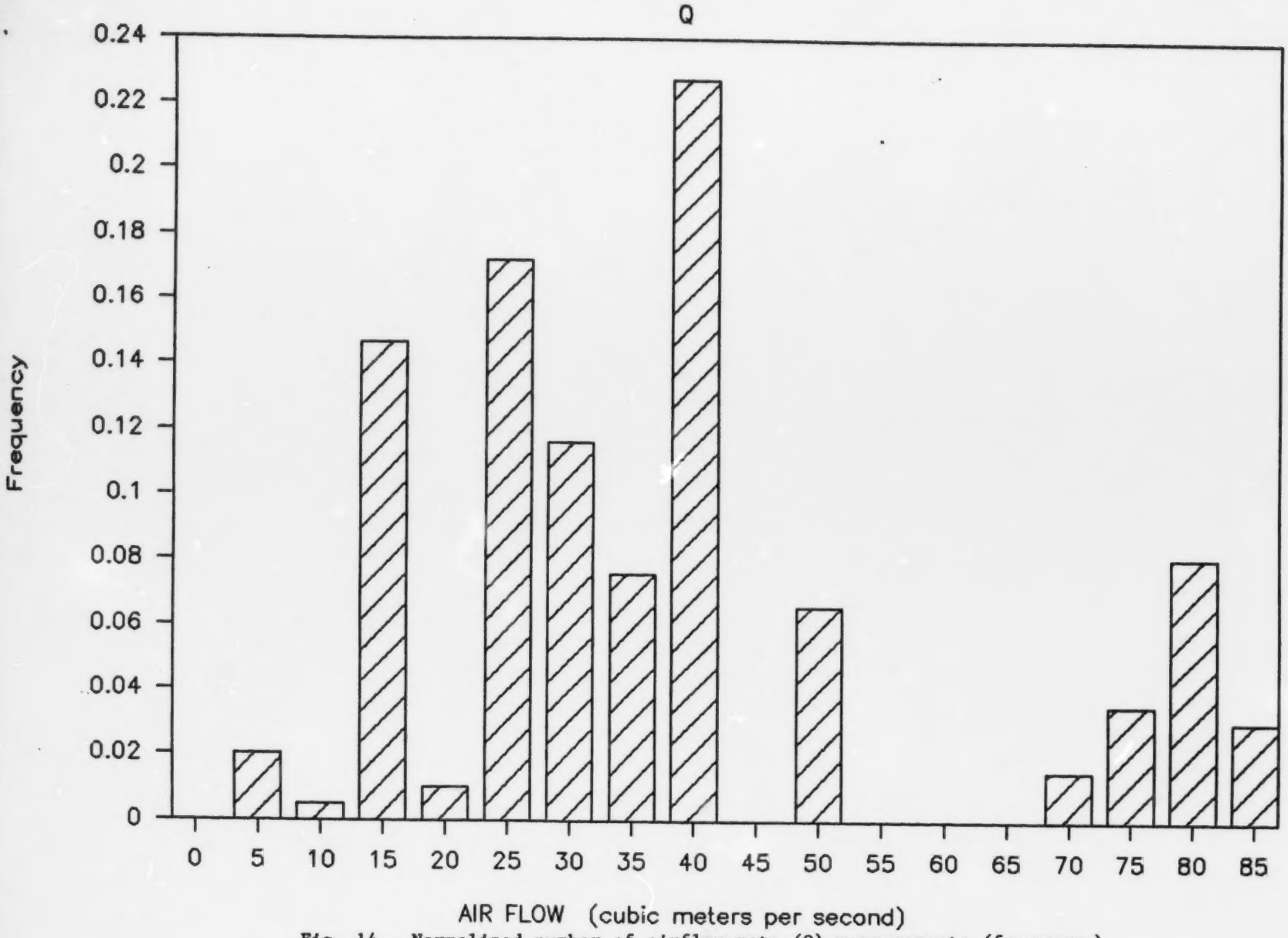

Fig. 14 - Normalized number of airflow rate (Q) measurements (frequency) versus Q taken at different U/G locations.

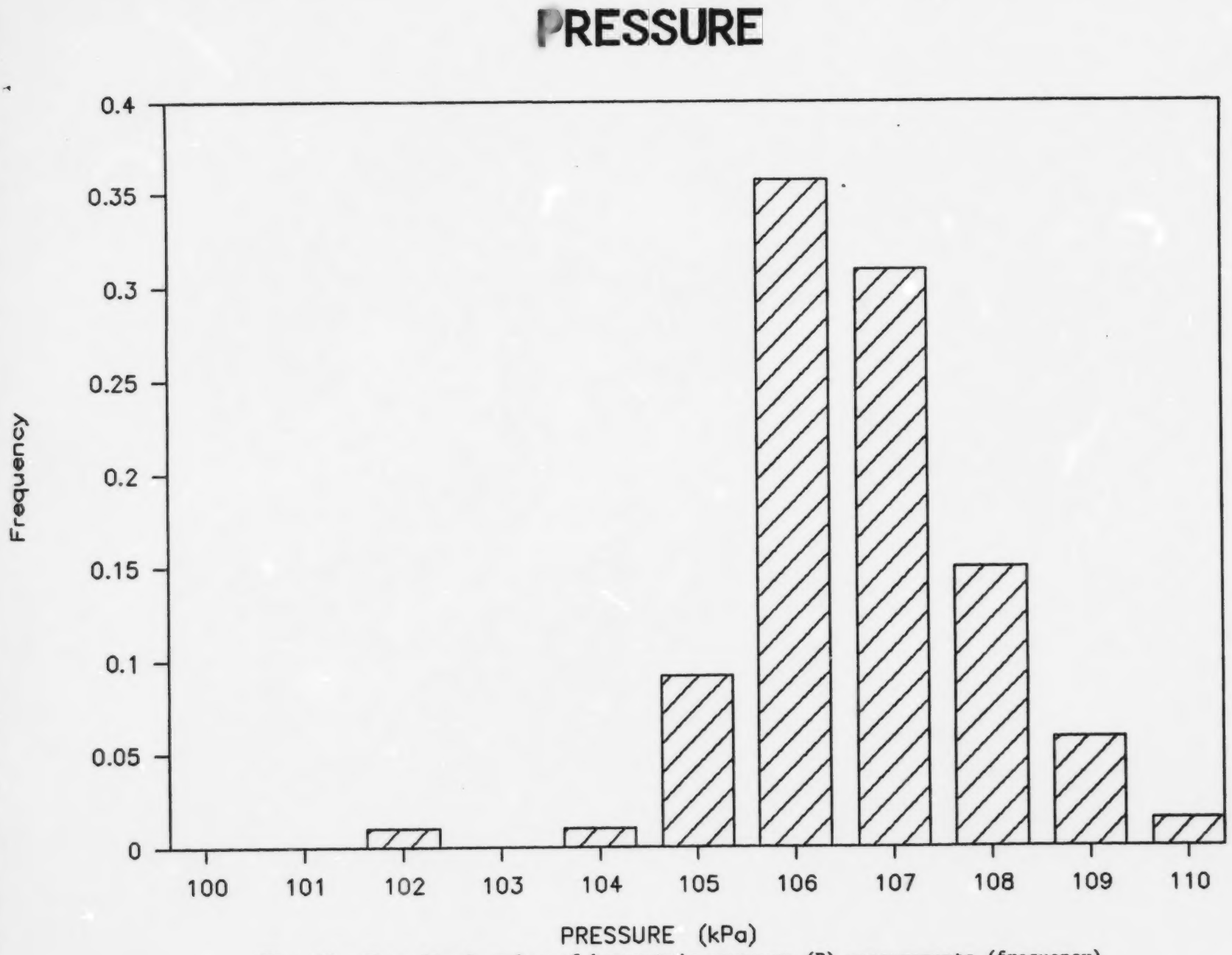

Fig. 15 - Normalized number of barometric pressure (P) measurements (frequency) versus P taken underground.

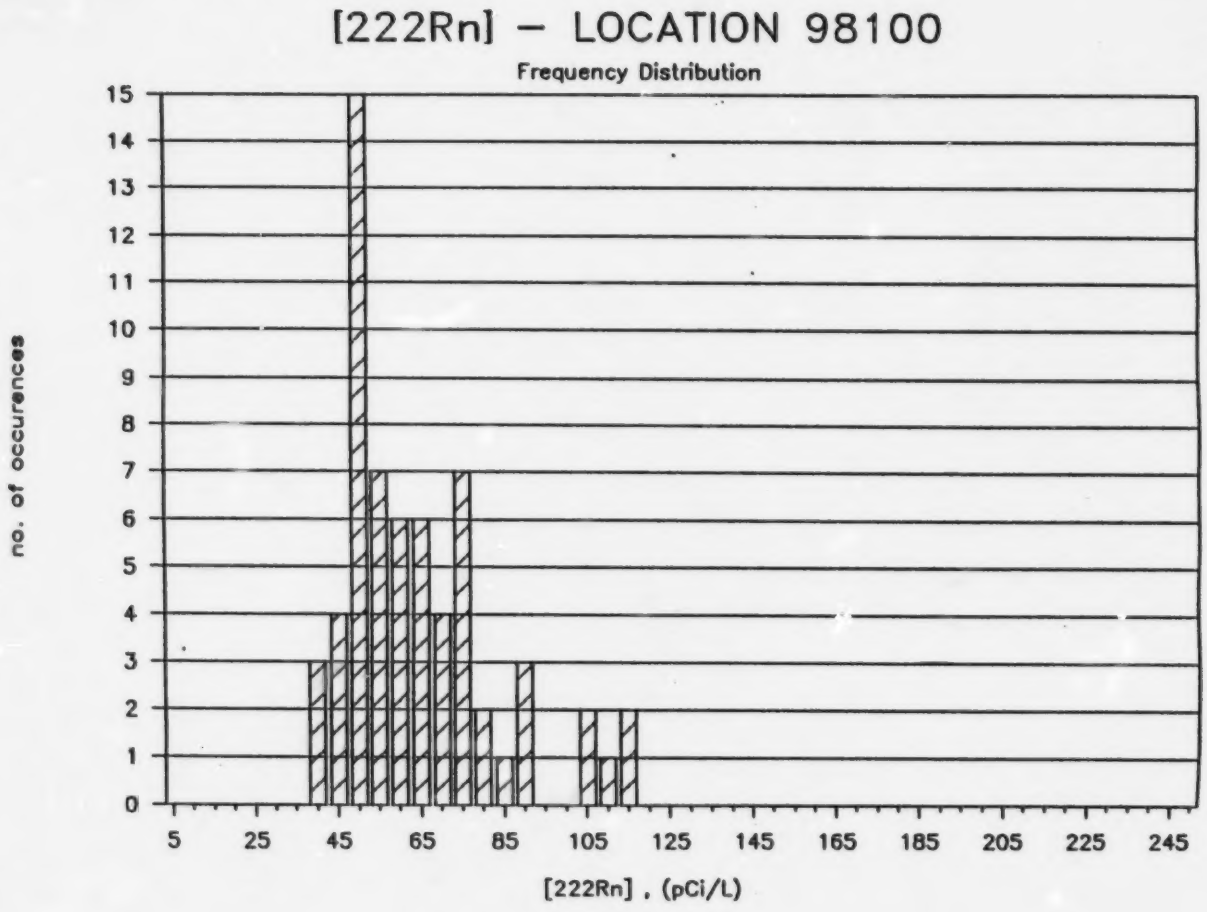

Fig. 16- Number of measurements of radon gas concentration, [^{222}Rn], versus [^{222}Rn] for location 98100 (footwall drive).

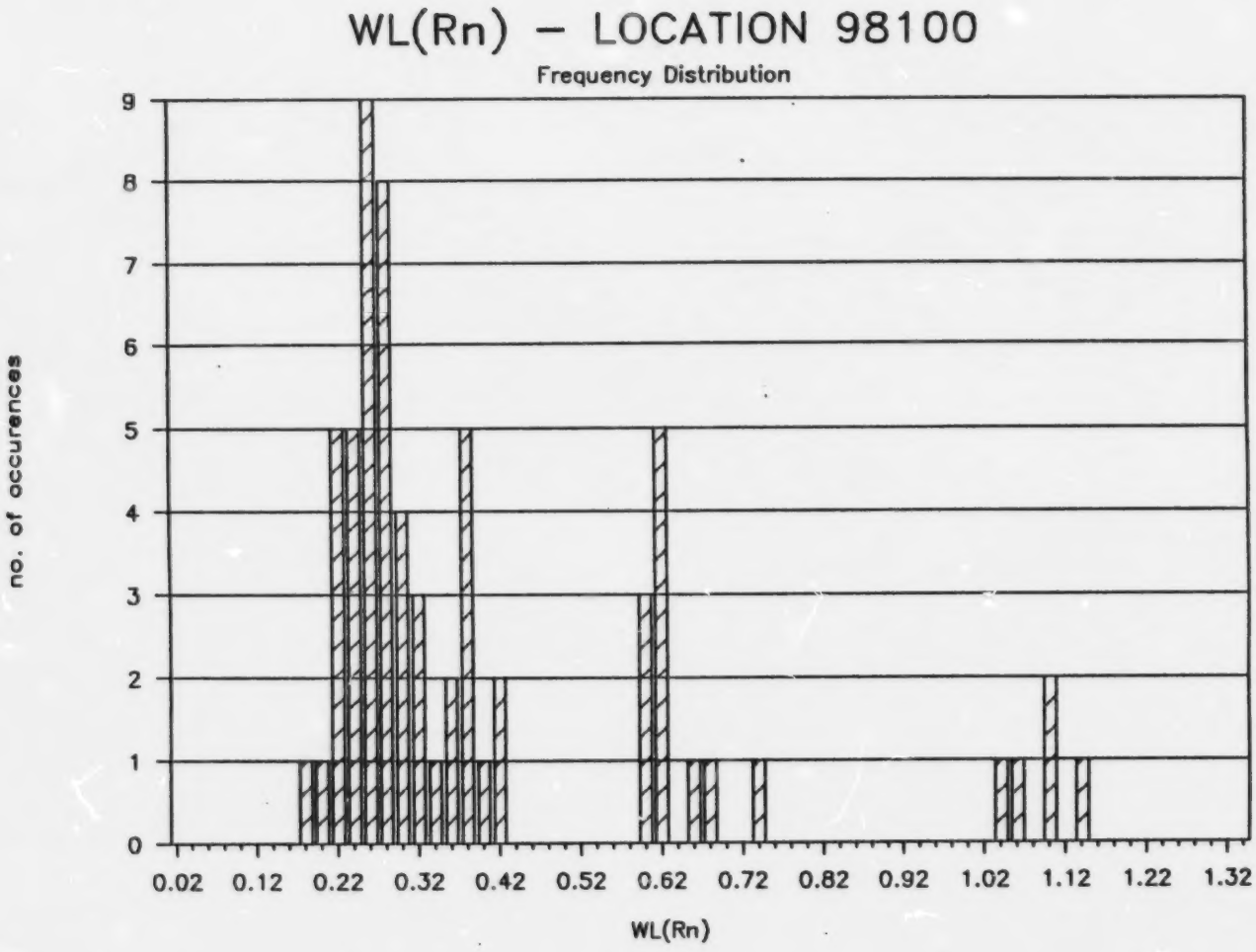

Fig. 17 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 98100 (footwall drive).

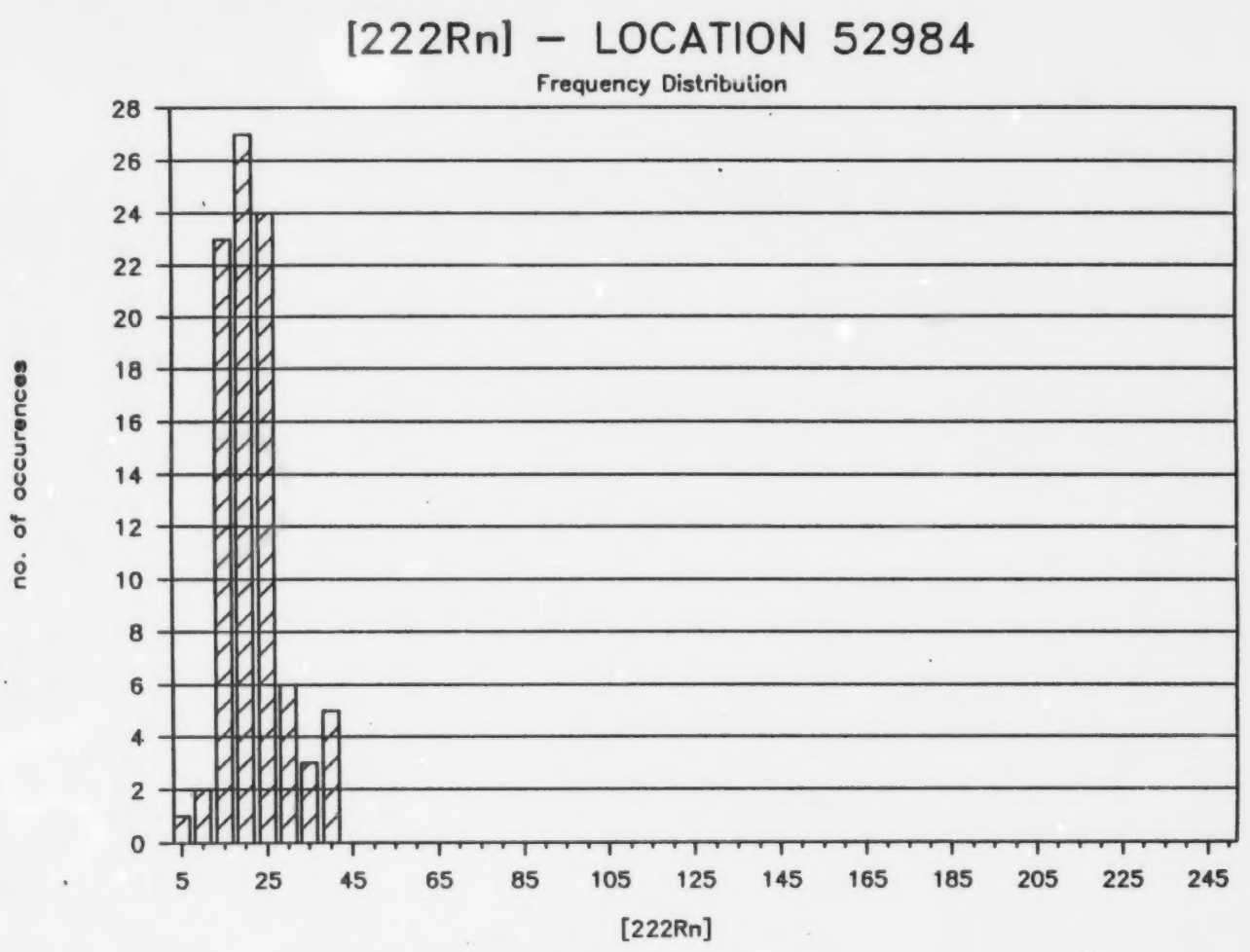

Fig. 18 - Number of measurements of radon gas concentration, [^{222}Rn], versus [^{222}Rn] for location 52984 (jumbo development heading).

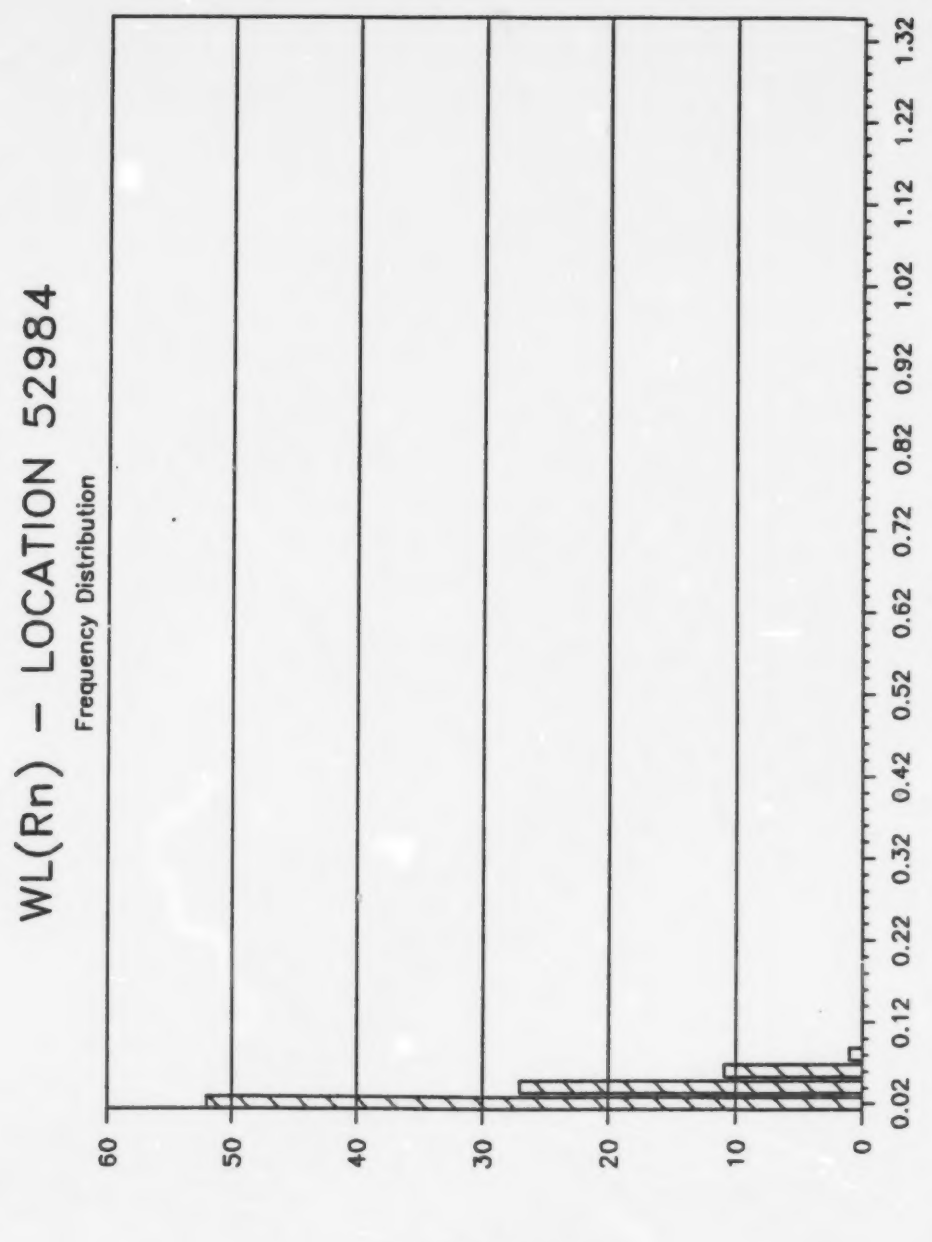

Fig. 19 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 52984 (jumbo development heading).

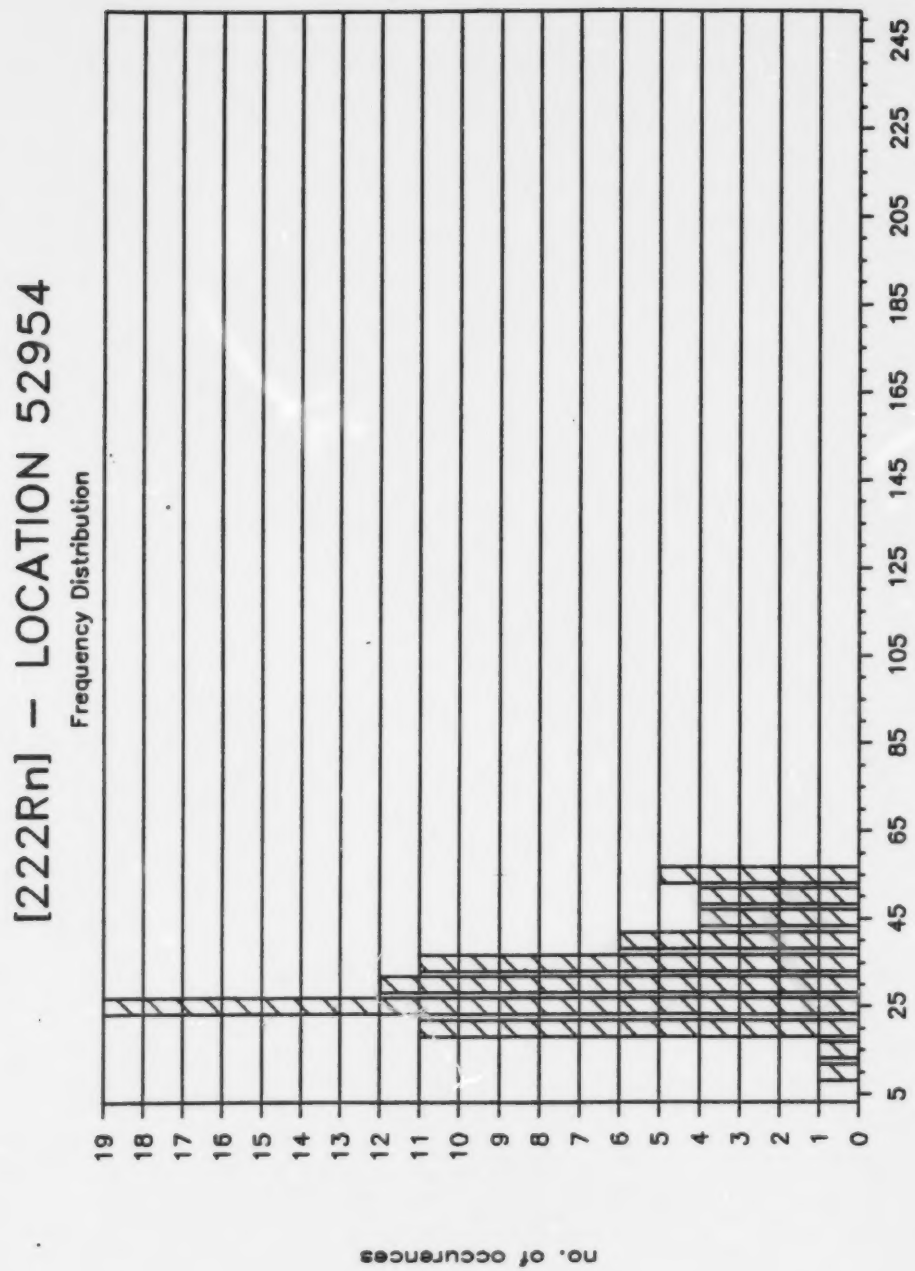

Fig. 20 – Number of measurements of radon gas concentration, [^{222}Rn], versus [^{222}Rn] for location 52954 (travelway).

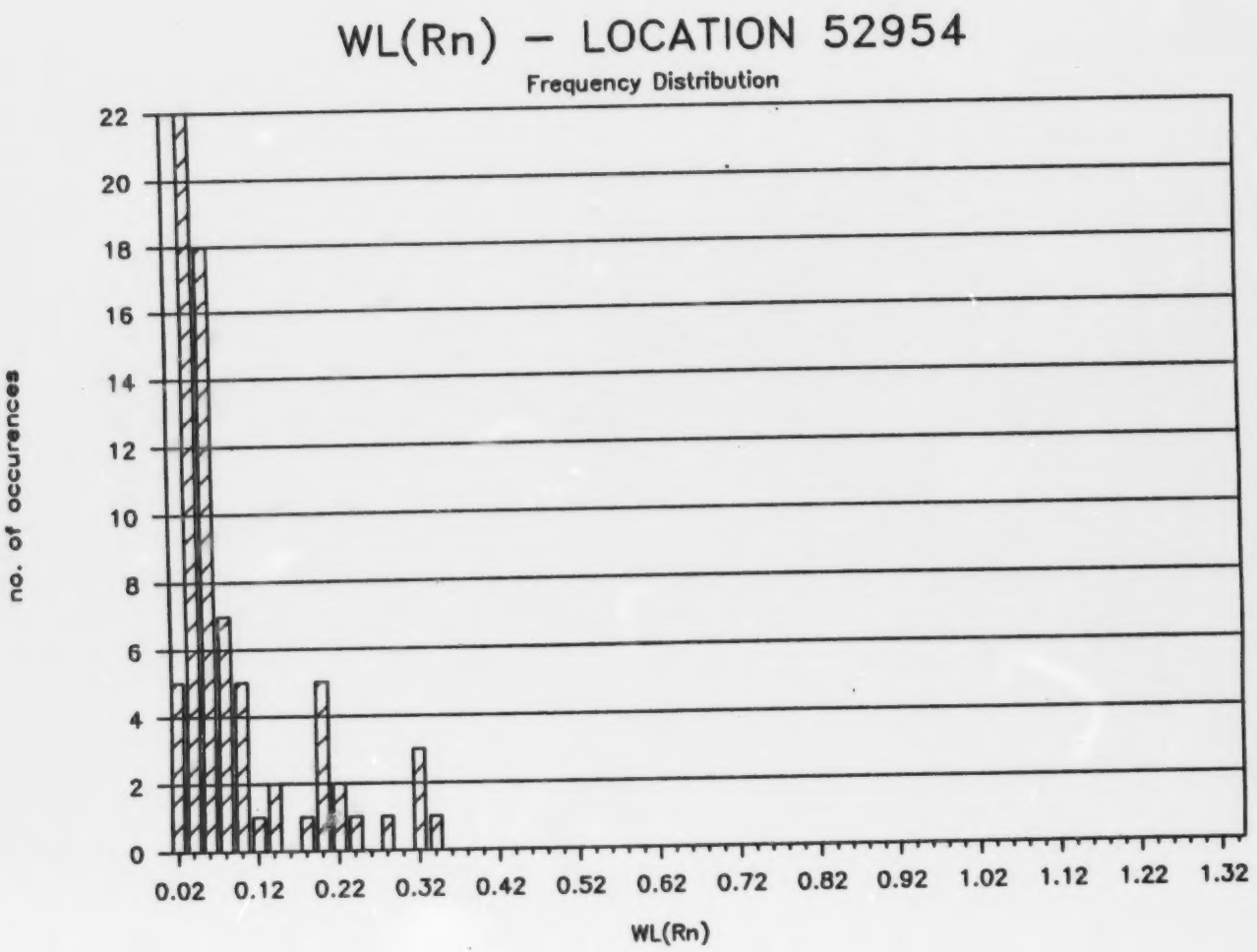

Fig. 21 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 52954 (travelway).

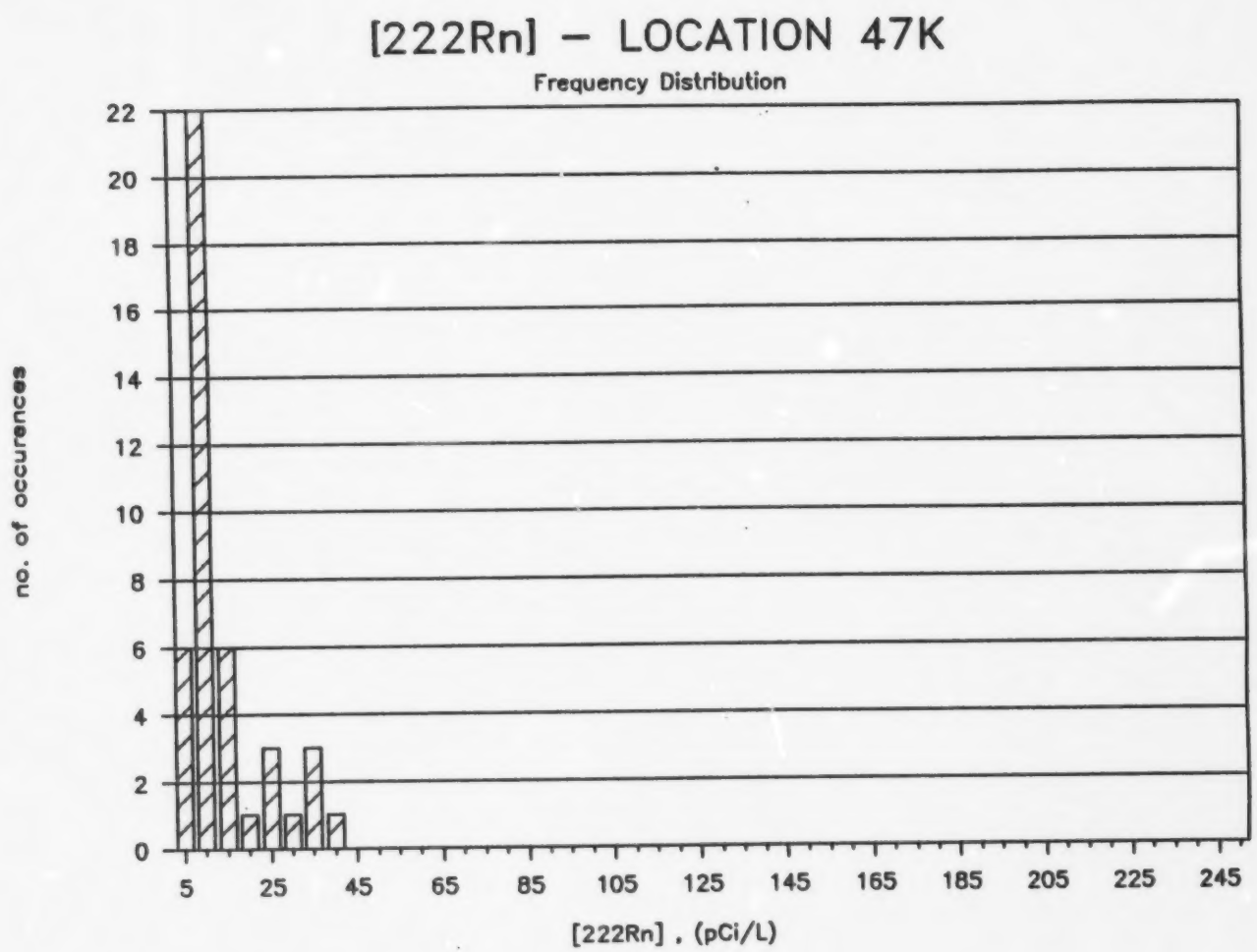

Fig. 22 - Number of measurements of radon gas concentration, [^{222}Rn], versus [^{222}Rn] for location 47 K (ramp in waste).

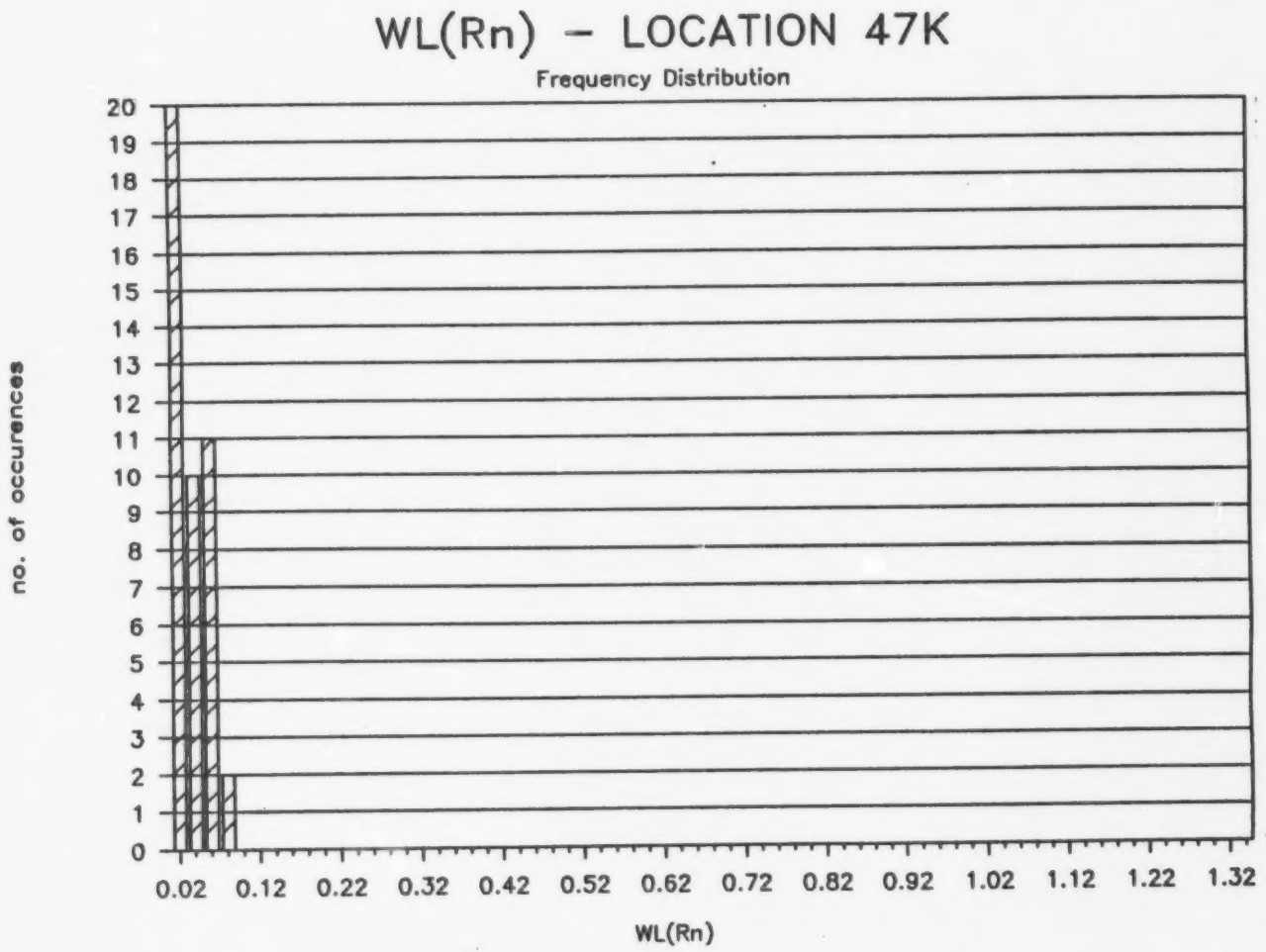

Fig. 23 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 47 K (ramp in waste).

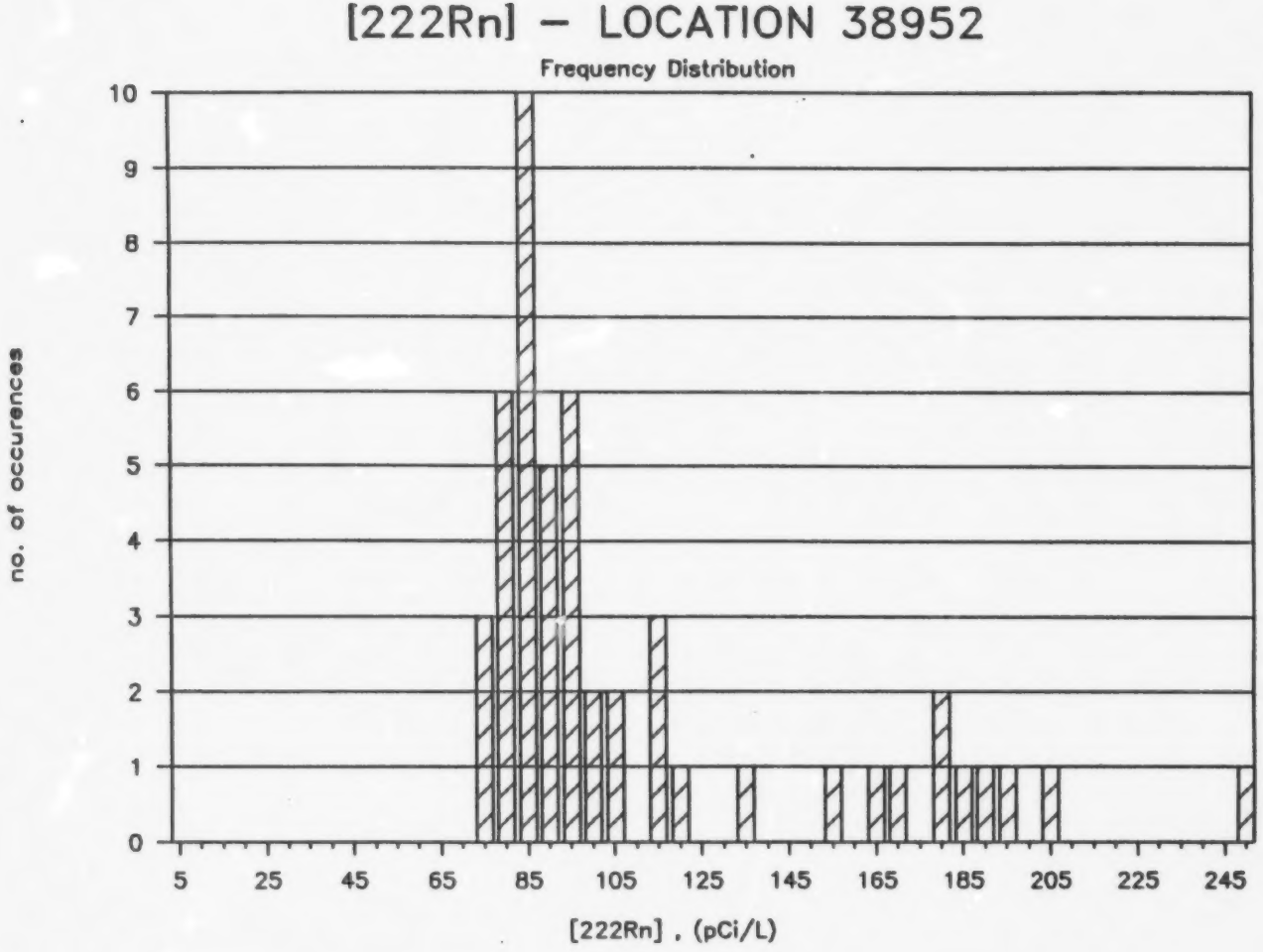

Fig. 24 - Number of measurements of radon gas concentration, $[^{222}Rn]$, versus $[^{222}Rn]$ for location 38952 (exhaust airway).

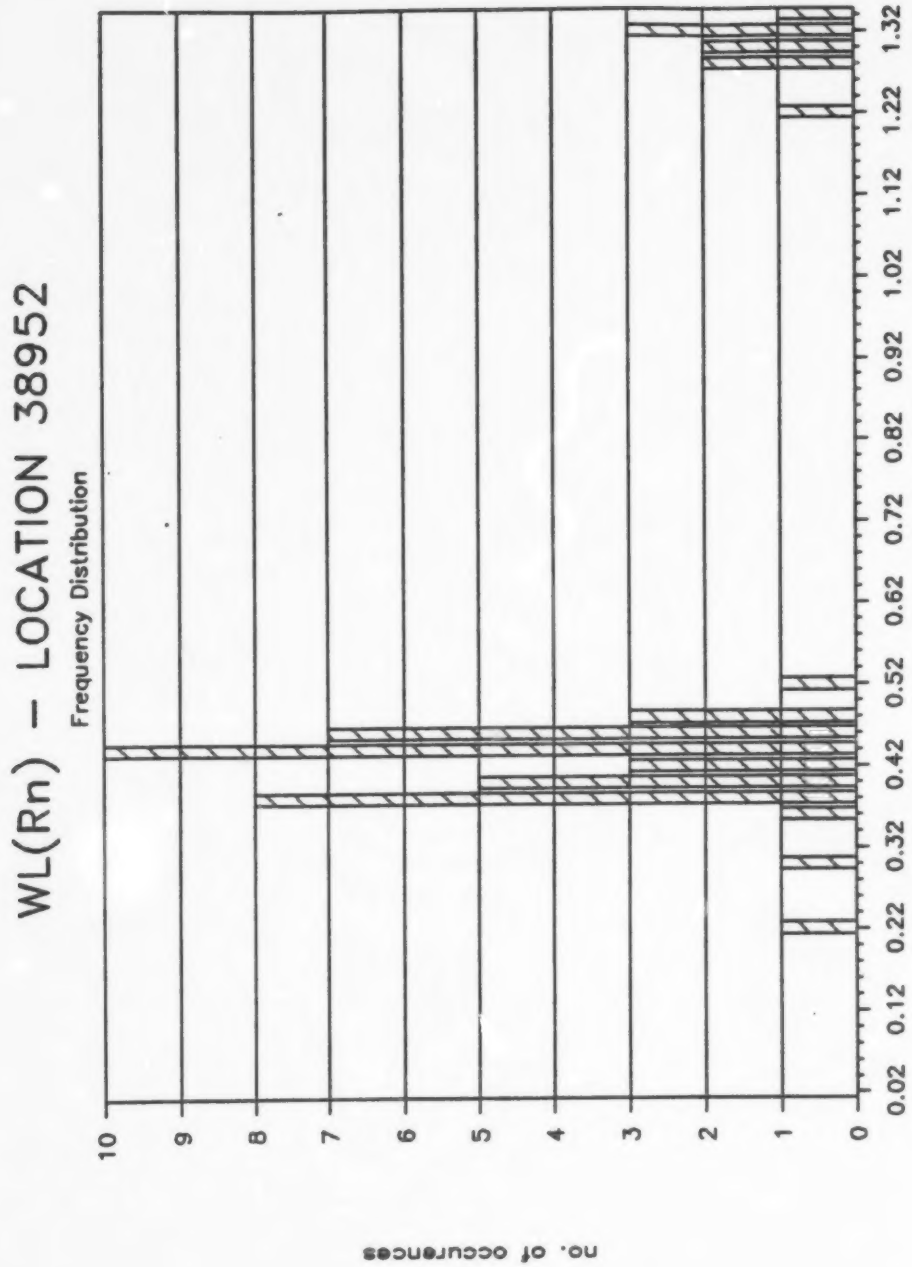

Fig. 25 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 38952 (exhaust airway).

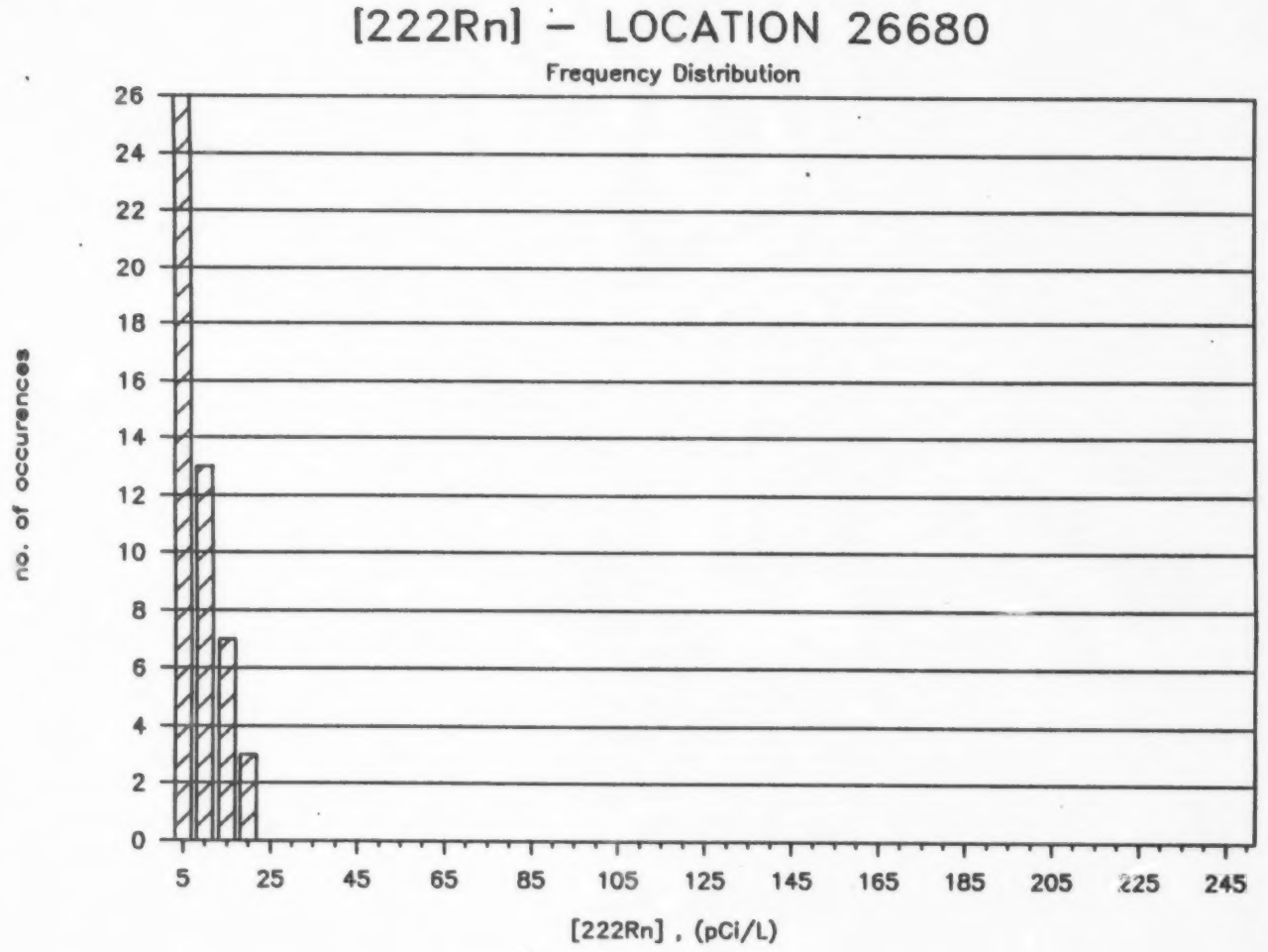

Fig. 26 - Number of measurements of radon gas concentration, [^{222}Rn], versus [^{222}Rn] for location 26680 (airway).

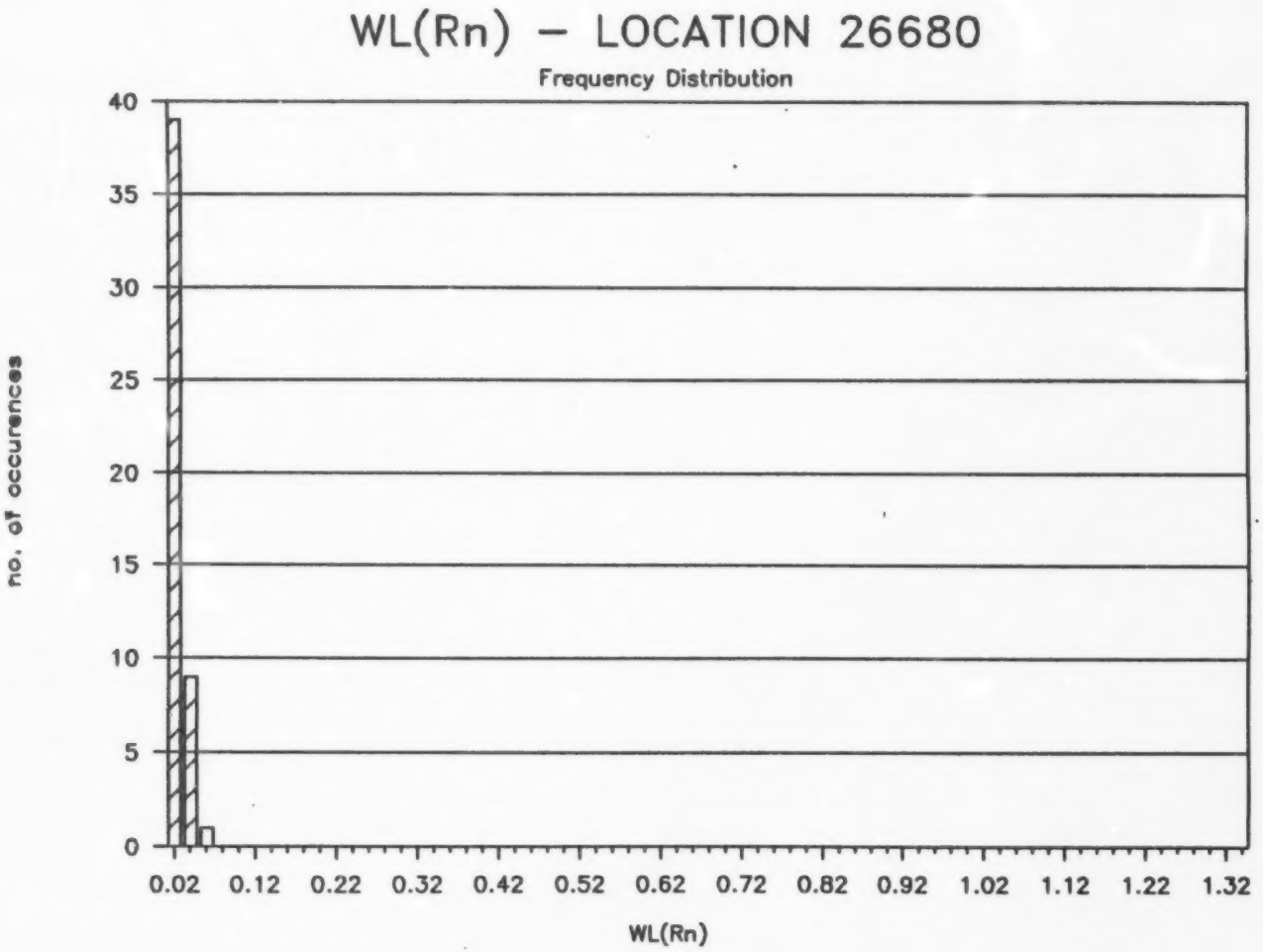

Fig. 27 - Number of measurements of radon progeny Working Level, WL(Rn), versus WL(Rn) for location 26680 (airway).

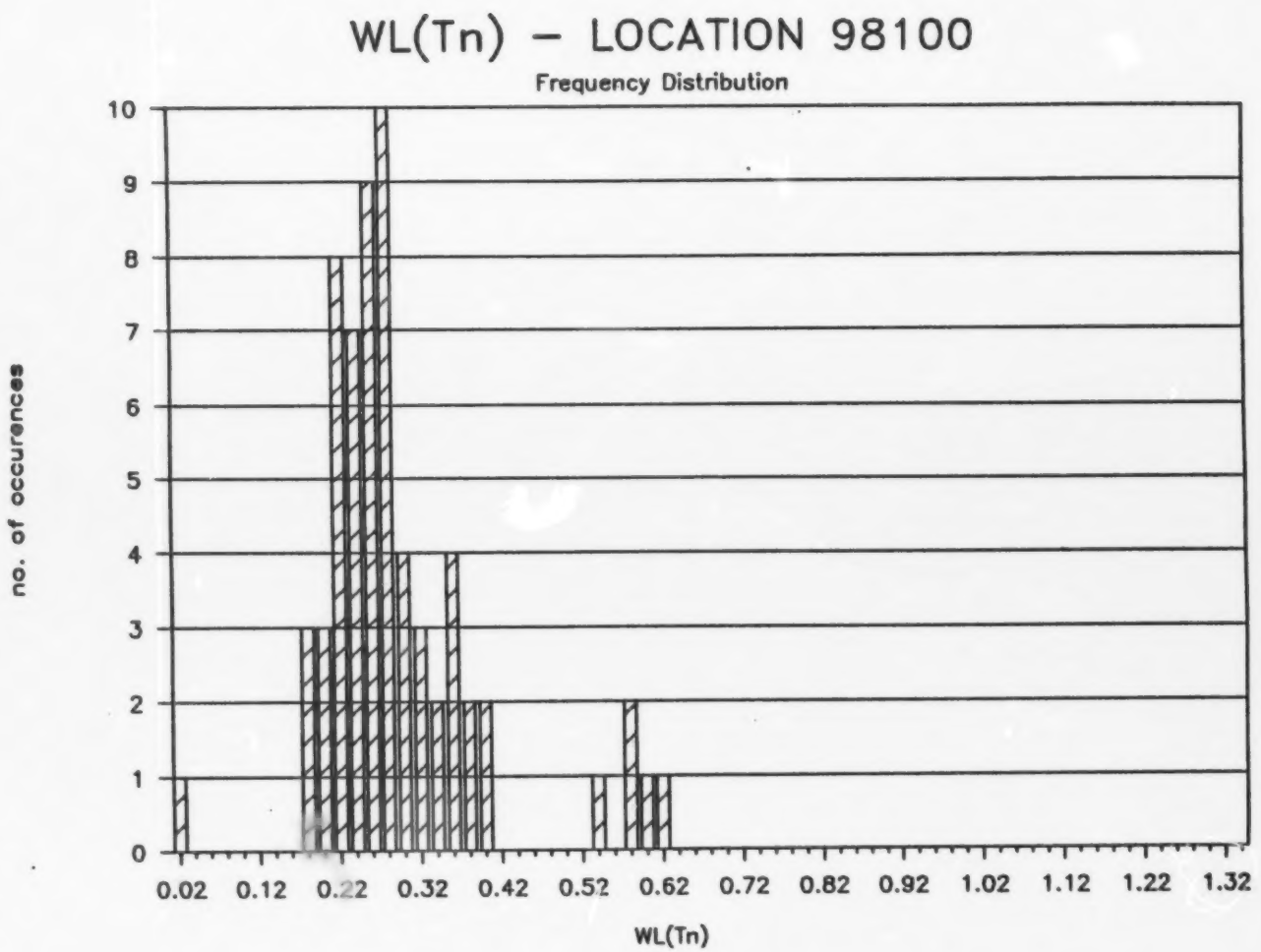

Fig. 28 - Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 98100 (footwall drive).

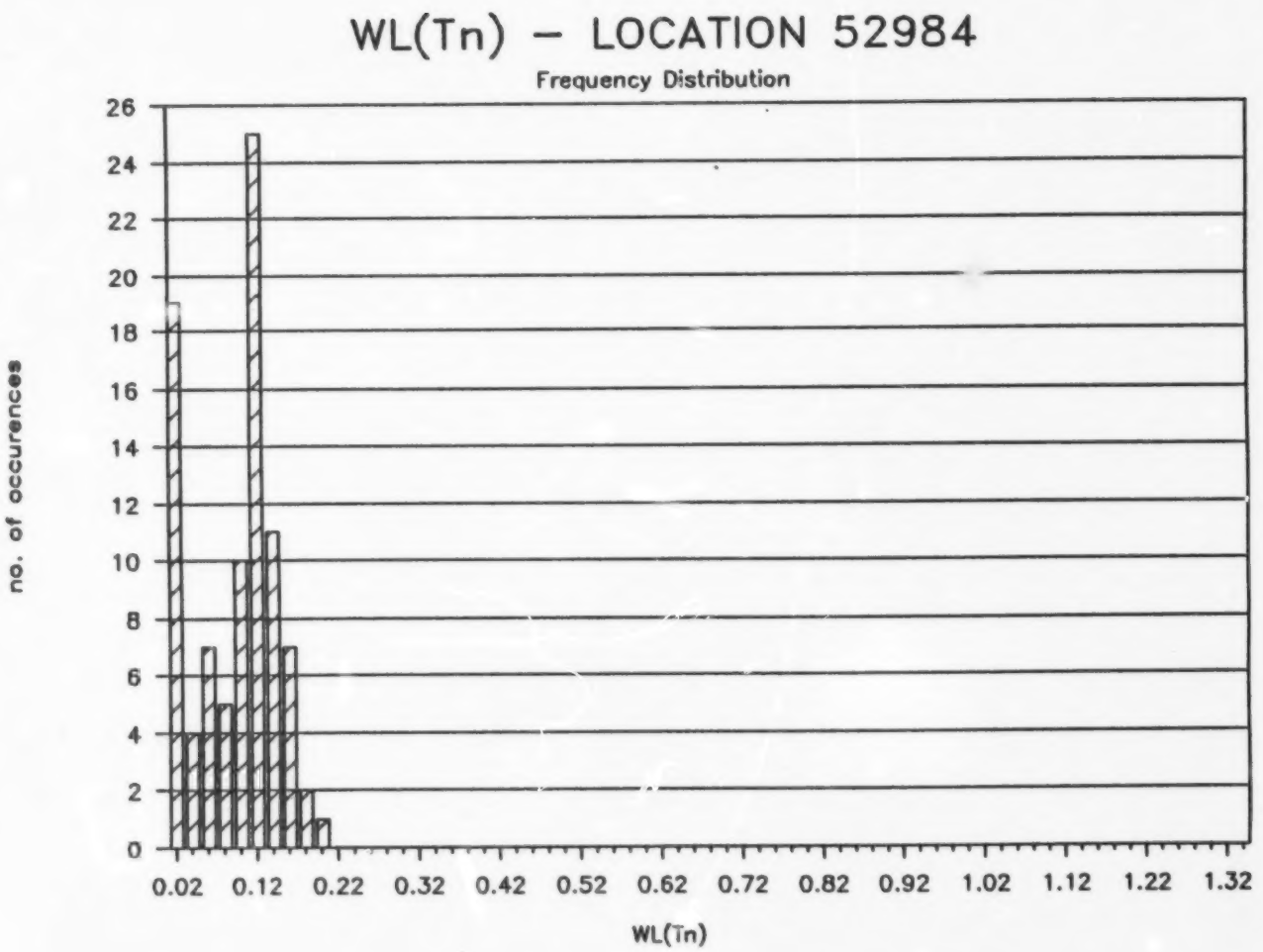

Fig. 29 - Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 52984 (jumbo development heading).

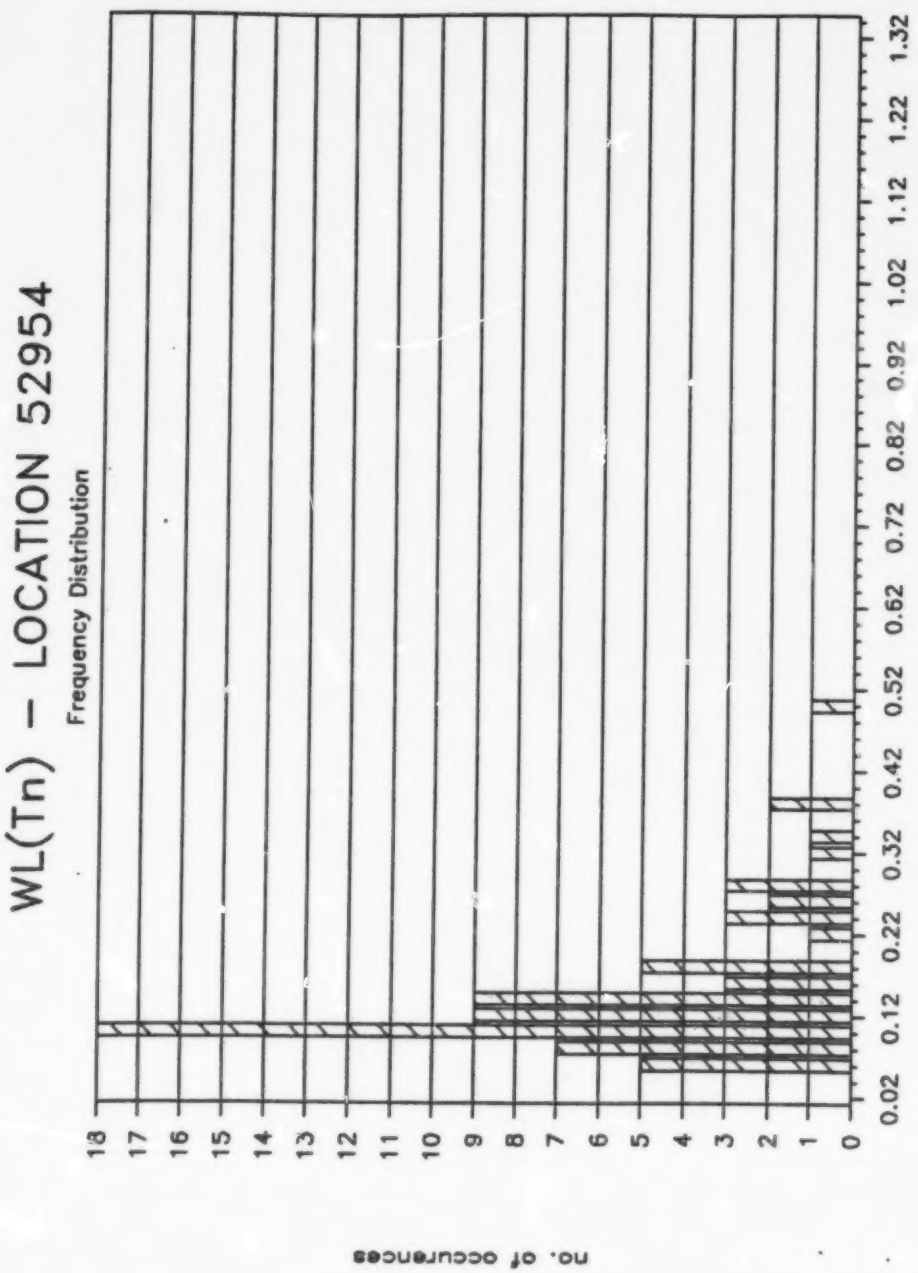

Fig. 30 – Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 52954 (travelway).

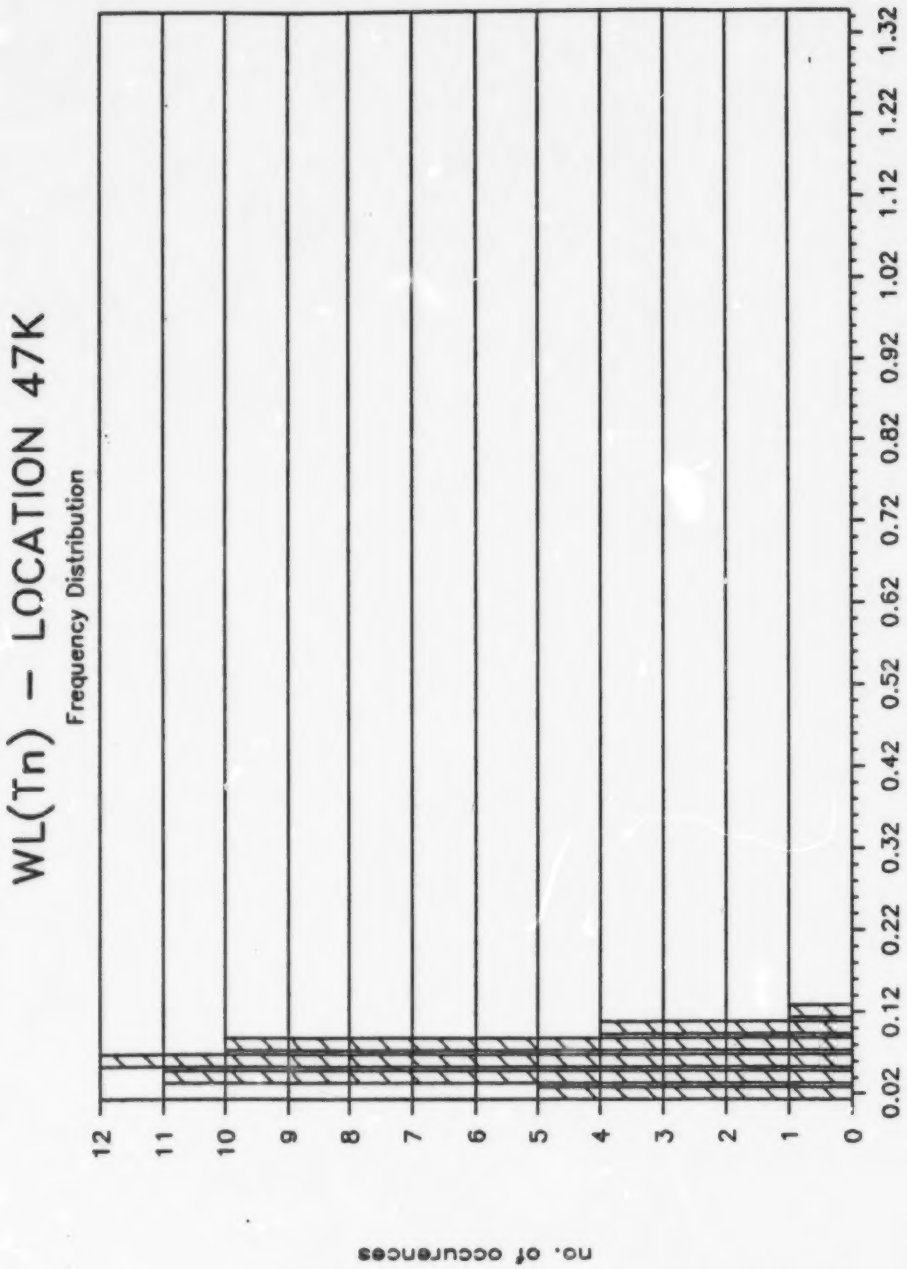

Fig. 31 - Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 47 K (ramp in waste).

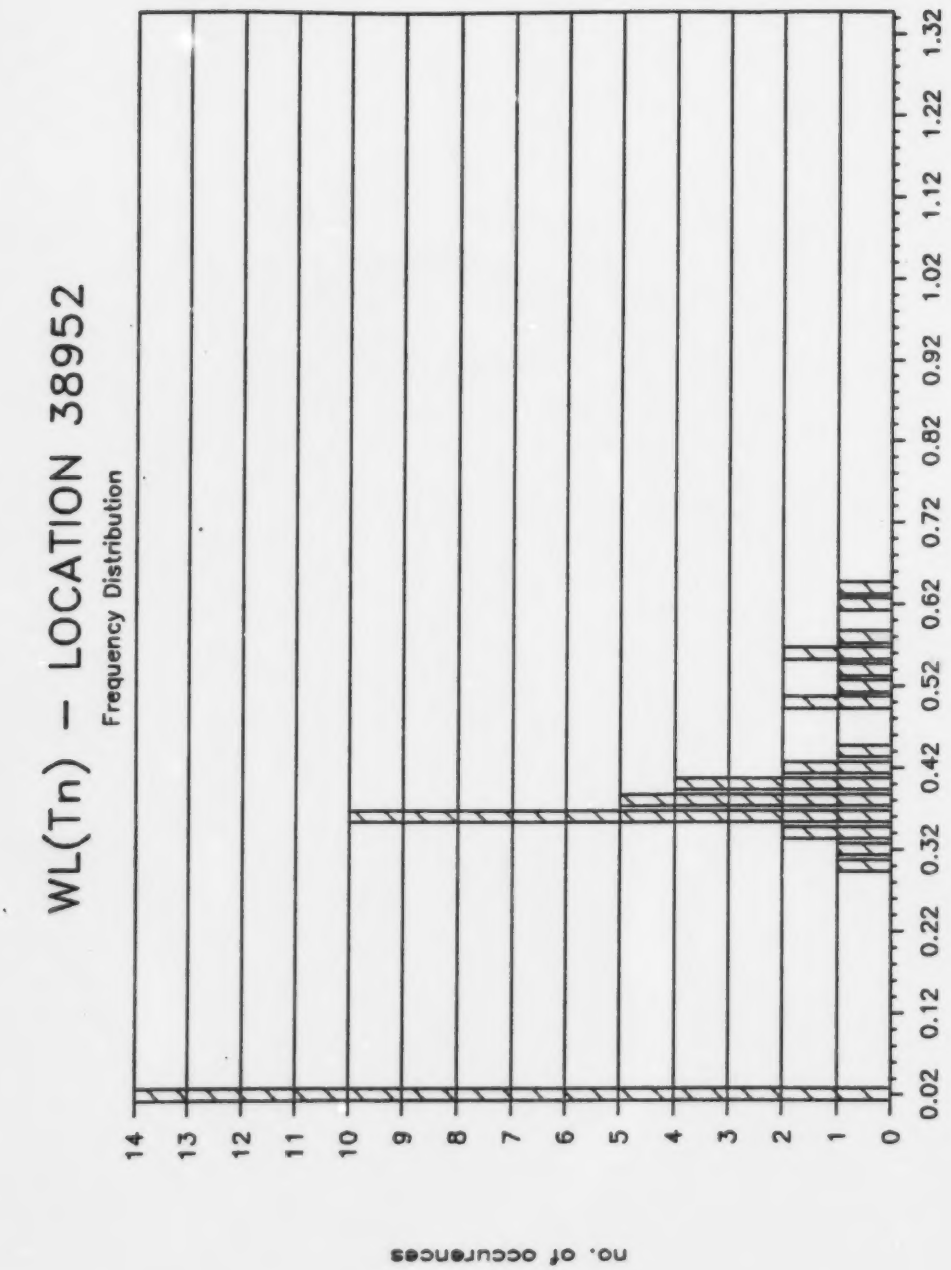

Fig. 32 – Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 38952 (exhaust airway).

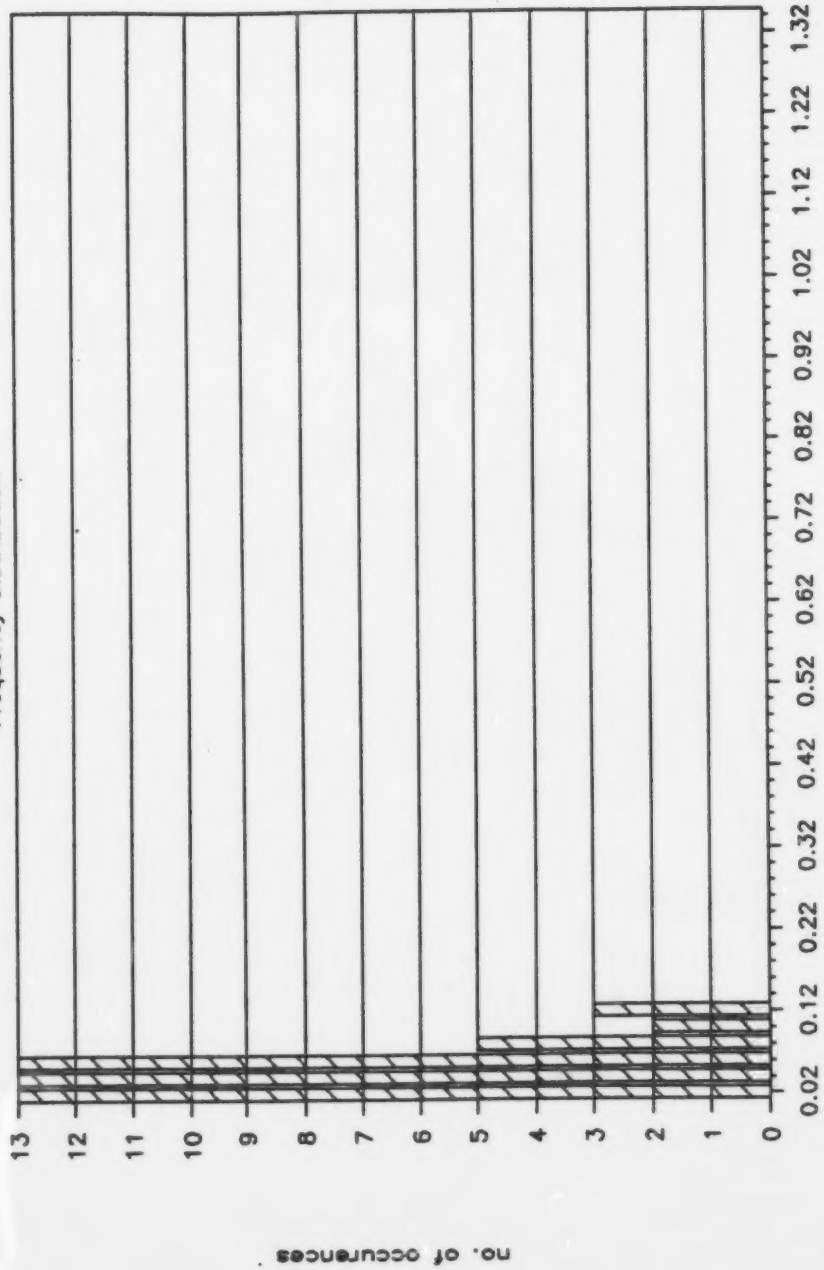

Fig. 33 - Number of measurements of thoron progeny Working Level, WL(Tn), versus WL(Tn) for location 26680 (airway).

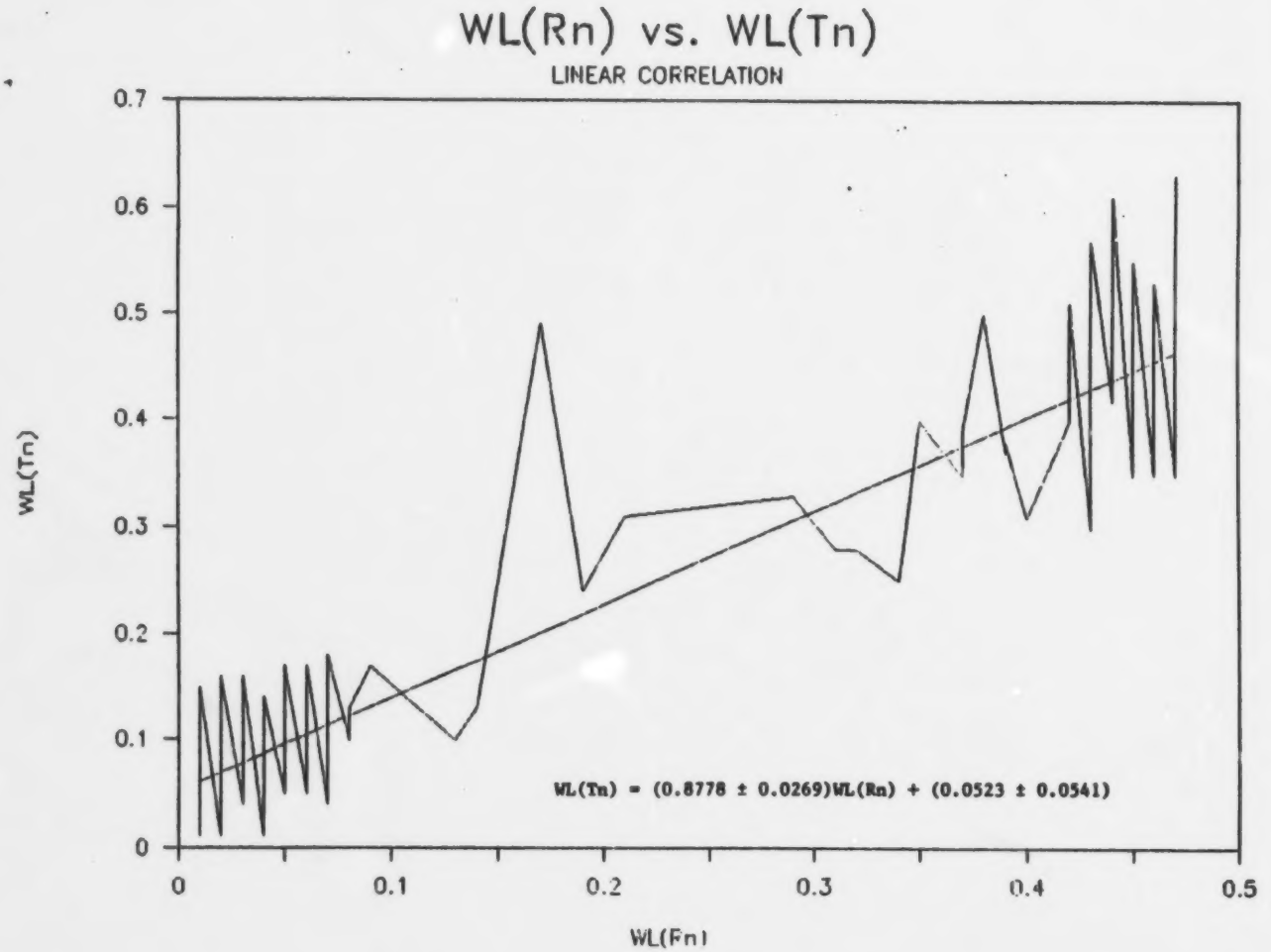

Fig. 34 - Thoron progeny Working Level, WL(Tn), versus radon progeny Working Level, WL(Rn). Points between the zig-zag line represent measurements or groups of measurements. The long straight line represents the best fitted line by regression analysis.

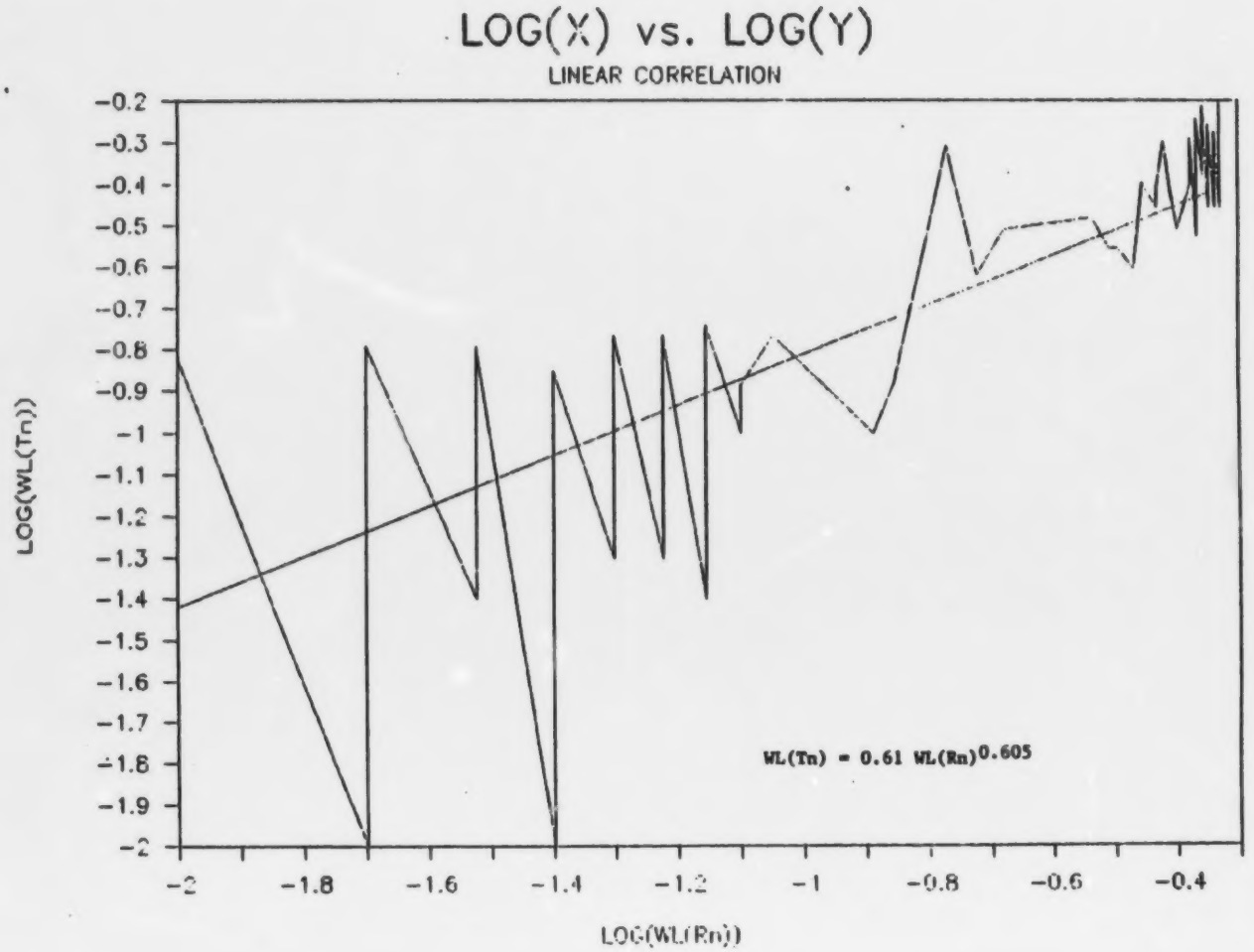

Fig. 35 - Log WL(Tn) versus log WL(Rn). Points between the zig-zag line represent measurements or groups of measurements. The long straight line represents the best fitted line by regression analysis.

TABLE 1

Miscellaneous data regarding conditions at mining locations

Emanation type

1 Shafts in waste
2 Drifts in ore
3 Ramps in waste
4.1 Jackleg stopes
4.2 Jumbo stopes
5 Empty stopes
6 Forced air ducts
7 Development headings
8 Exhaust shafts
9 Leaching stopes
10 Backfill stopes
11 Shops

Mining activity

0 Inactive

PRODUCTION

11 Setting up, misc. work
12 Bolting, scaling
13 Drilling on face
14 Loading anfo
15 Mucking with scoop
16 Slushing
17 Diamond Drilling

GENERAL

21 Airway (no traffic)
22 Airway (traffic)
23 Travelway (no traffic)
24 Travelway (traffic)
25 Construction
26 Haulage equipment loading
27 Shops

LEACHING

30 Leaching sprays off
31 Leaching sprays on
32 Flood Leaching

BACKFILL

41 Pouring backfill

Ventilation

0 Nil
1 F.T.V.
2 Aux. fan, duct
3 Booster fans

Back and walls

1 Smooth (flat)
2 Minor blocks (regular)
3 Blocky & some slabs
4 Very blocky & slabs
5 Extreme
DECIMAL: .1 Painted
.2 Shotcrete

Floor

0 Clean
1 Minor muck cover packed
2 Minor muck cover loose
3 Major muck cover packed
4 Major muck cover loose
6 Fines
7 Backfill
DECIMAL: .1 Loose muck piled on roadway

Ground Conditions

0 Very minor features
1 Minor fractures
2 Regular fractures
3 Major fractures
4 Fault Area
DECIMAL: .1 Basement Exposed
.2 Waste Exposed
.3 Dyke or dykelets exposed

Water

1 Very dry
3 Normal wet road
5 Very wet
DECIMAL: .1 Oil etc, on road
.2 Small pools of water
.3 Large pools of water
.4 Minor flowing water
.5 Major flowing water
.6 Ground water coming through walls or back

Unusual Conditions

0 Normal
1 Traffic started upstream
2 Traffic stopped upstream
3 Change in airflow
4 Sampling equipment problem
5 Other (see memo)

TABLE 2

Description of sampling locations

Emanation Type	Initial Station	Final Station	Location Description
1.00	101.00	102.00	#2 shaft
	103.00	104.00	N.W. raise
2.00	301.00	302.00	26680 airway
	303.00	308.00	49663 area exhaust
	303.00	304.00	49683 airway
	303.00	307.00	49683 airway
	402.00	401.00	45983 exhaustway
	403.00	402.00	45983 exhaustway
	404.00	401.00	45983 exhaustway
	404.00	403.00	45983 exhaustway
	408.00	410.00	95167 travelway across idle stopes
	409.00	410.00	95167 travelway across idle stopes
	412.00	419.00	53951 travelway
	413.00	412.00	53951 travelway
	415.00	412.00	53951 travelway
	416.00	415.00	53951 travelway
	418.00	414.00	95353 airway
	430.00	434.00	45964 travelway
	431.00	434.00	45964 travelway
	501.00	502.00	57882 airway
	504.0	505.00	57852 travelway
	505.00	506.00	57852 travelway
	506.00	507.00	57852 travelway
	508.00	509.00	59882 airway
	510.00	511.00	52952 travelway
	601.00	602.00	52984 airway
	601.00	602.10	52984 airway prior to fault
	602.00	603.00	52984 airway
	602.10	602.20	52984 airway across fault zone
	602.20	603.00	52984 airway after fault zone
	603.00	604.00	52984 travelway
	607.00	608.00	52984 travelway
	608.00	610.00	52984 travelway
	610.00	611.00	52984 travelway
	613.00	616.00	50966 mining area
	613.10	613.00	52106 airway
	701.00	702.00	38954 travelway
	702.00	703.00	38954 travelway
	703.00	705.00	38954 travelway
	705.00	707.00	38954 travelway
	707.00	708.00	38954 travelway
	801.00	802.00	38952 exhaust airway

Cont.

Table 2 - cont.

Emanation Type	Initial Station	Final Station	Location Description
3.00	202.00	201.00	Surface ramp (upper protion) in waste
	203.00	204.00	Footwall drive in waste
	205.00	206.00	Footwall drive in waste
	208.00	207.00	Crusher decline in waste
	209.00	210.00	47K ramp in waste
	209.00	209.10	47K ramp in waste
	210.00	211.00	47K ramp in waste
4.10	417.00	417.10	53007 jackleg stope
	420.00	420.10	53006 jackleg stope
	421.00	421.10	53004 jackleg stope
	702.00	702.10	38071 jackleg stope
	703.00	704.10	38070 jackleg stope
	705.00	706.10	38068 jackleg stope
	708.00	708.10	38062 jackleg stope
	708.00	708.10	38062 jackleg stope
4.20	608.00	609.19	52113 jumbo stope
	613.00	615.10	50106 jumbo stope
5.00	405.00	405.10	51010 idle stope
	406.00	406.10	51011 idle stope
7.00	307.00	306.10	49663 jumbo development heading
	603.00	605.10	52984 jumbo development heading
	604.00	606.10	52954 jumbo development heading
	613.00	614.10	50966 jumbo development heading
	617.00	617.10	52984 jumbo development heading
9.00	901.00	902.00	40144 leaching area
	902.00	902.10	40144 leaching area
	904.00	905.00	43951 leaching area
11.00	433.00	433.10	Salvage shop

TABLE 3

Radon Concentration, Radon progeny, Thoron progeny and mining activity

for several locations underground

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	WL (Rn) x10^{2} [^{222}Rn]	WL(Tn) WL(Rn)
26680	86/10/05	9.06 ± 5.3	0.015 ± .01	n/a	21	0.16	-
	86/12/22	2.73 ± 2.0	0.001 ± .003	0.088 ± .03	21	0.04	88.00
	87/03/09	4.87 ± 4.6	0.011 ± .01	0.040 ± .02	21	0.22	3.64
	87/04/29	2.41 ± 1.8	0.008 ± .004	0.046 ± .02	21	0.33	5.75
	87/06/01	10.08 ± 3.7	0.037 ± .01	0.039 ± .02	21	0.37	1.05
38068	87/01/06	46.03 ± 8.23	0.088 ± .02	0.126 ± .02	16	0.19	1.43
	87/01/12	30.94 ± 4.60	0.050 ± .02	0.070 ± .02	23	0.16	1.40
	87/01/12	50.91 ± 3.10	0.085 ± .010	0.080 ± .01	12	0.17	0.94
	87/01/14	43.28 ± 6.00	0.082 ± .004	0.090 ± .01	23	0.19	1.10
	87/01/14	78.82 ± 18.50	0.122 ± .007	0.100 ± .02	12	0.15	0.87
38070	87/01/08	24.76 ± 7.50	0.037 ± .005	0.071 ± .024	13	0.15	1.92
	87/01/08	41.37 ± 7.20	0.087 ± .008	0.092 ± .02	16	0.21	1.06
38954	87/04/02	18.42 ± 12.9	0.028 ± .02	0.062 ± .013	23	0.15	2.21
	87/03/10	10.60 ± 2.3	0.023 ± .006	0.053 ± .04	23	0.22	2.30
	87/03/10	22.23	0.020	0.110	11	0.09	5.50
38952	86/12/18	90.78 ± 15.2	0.432 ± .03	0.525 ± .09	21	0.48	1.21
	87/03/05	85.61 ± 9.9	0.369 ± .03	0.370 ± .02	21	0.43	1.00
	87/05/05	83.75 ± 6.2	0.443 ± .02	0.371 ± .04	21	0.53	0.84
38071	87/04/02	25.12 ± 1.7	0.030	0.078 ± .02	13	0.12	2.60
	87/04/06	38.42 ± 16.2	0.037 ± .001	0.040 ± .02	13	0.10	1.08
	87/04/06	10.49 ± 2.9	0.035 ± .01	0.025 ± .02	23	0.33	0.71
38062	87/05/26	61.60 ± 2.4	0.300 ± .01	0.010 ± .01	23	0.49	0.03
	87/05/26	74.74 ± 37.6	0.335 ± .09	0.205 ± .18	11	0.45	0.61
43951	87/06/11	148.76 ± 3.6	0.76 ± .05	0.41	31	0.51	0.54
49683	87/01/28	8.69 ± 3.4	0.00	0.065 ± .03	21	-	-
	87/01/28	9.72 ± 7.4	0.005 ± .006	0.056 ± .02	14	0.05	11.20
	87/03/23	5.69 ± .41	0.005 ± .007	0.040 ± .03	21	0.09	8.00
	87/03/23	6.88 ± 1.17	0.010 ±	0.060	17	0.14	6.00
	87/04/14	17.53 ± 9.7	0.057 ± .06	0.07 ± .04	21	0.32	1.23
49663	87/01/29	9.28 ± 2.2	0.018 ± .007	0.050 ± 0.13	12	0.19	2.78
	87/01/29	5.25 ± .35	0.01	0.030 ± .02	23	0.19	3.00
	87/03/23	9.99 ± 4.43	0.023 ± .006	0.053 ± .01	17	0.23	2.30
	87/03/23	11.12 ± 4.81	0.030	0.020	23	0.27	0.67
	87/04/14	39.44 ± .91	0.220 ± .02	0.135 ± .01	0	0.56	0.61
	87/04/14	14.24 ± .99	0.025 ± .01	0.065 ± .01	23	0.18	2.60

Cont.

Table 3 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	WL (Rn) x10^{3} / [^{222}Rn]	WL(Tn) / WL(Rn)
45983	86/12/23	199.0 ± 30.8	1.64 ± .17	0.694 ± .115	24	8.82	0.42
	87/03/12	181.32 ± 25.08	1.86 ± .38	0.343 ± .201	23	1.00	0.18
	87/05/14	1203 ± 32.3	0.86 ± .29	0.346 ± .15	23	0.72	0.40
40143	87/04/28	2130.27	10.34	0.15	0	0.48	0.01
40144	87/05/07	0.97	0.07	N/A	21		
	87/05/07	155.5 ± 115.8	0.69 ± .79	N/A	0	0.44	
52954	87/01/26	28.18 ± 3.6	0.49 ± .01	0.142 ± .03	0	0.17	2.90
	87/04/13	34.13 ± 9.7	0.087 ± .02	0.103 ± .011	24	0.25	1.18
	87/04/30	35.93 ± 13.34	0.154 ± .124	0.165 ± .102	24	0.43	1.07
	87/06/02	26.2 ± 2.9	0.05	0.103 ± .02	26	0.19	2.06
	87/07/27	24.7 ± 4.6	0.068 ± 0.02	N/A	21	0.27	
52984	86/12/04	12.21 ± 2.9	0.006 ± .007	0.091 ± .04	21	0.05	15.17
	86/12/09	23.3 ± 6.05	0.041 ± .01	0.132 ± .03	23	0.18	3.22
52113	86/12/08	28.64 ± 10.3	0.039 ± .02	0.199 ± .03	26	0.14	5.10
	87/01/19	30.54 ± 6.5	0.063 ± .01	0.148 ± .034	0	0.21	2.35
	87/04/13	53.27 ± 0.48	0.210 ± .026	0.170 ± .02	25	0.39	0.81
50106	87/01/20	41.33 ± 5.68	0.141 ± .022	0.177 ± .05	0	0.[illegible]	1.25
	87/01/21	43.62	0.12	0.24	12	0 [illegible]	2.00
	87/05/06	44.03 ± 4.8	0.167 ± .006	0.22 ± .04	24	0.38	1.32
	87/05/06	55.65 ± 15.4	0.203 ± .02	0.22 ± .02	0	0.36	1.08
CR.DEC	87/01/15	11.15 ± 3.32	0.031 ± .01	0.077 ± .01	24	0.28	2.48
	87/01/15	9.39 ± 1.15	0.033 ± .05	0.097 ± .01	23	0.35	2.94
NWE U/G	87/06/04	1.99 ± 1.5	0	0.01 ± .01	21	-	-
	87/06/04	4.88	0.01	0.03	42	0.20	3.00
98100	86/12/29	48.27 ± 3.3	0.269 ± .02	0.312 ± .110	21	0.56	1.16
	87/01/05	77.62 ± 32.01	0.694 ± .42	0.445 ± 0.15	21	0.89	0.64
	87/03/25	47.77 ± 6.5	0.227 ± 0.02	0.207 ± 0.3	23	0.47	0.91
	87/03/26	70.0 ± 11.30	0.474 ± .141	0.272 ± .03	23	0.68	0.57
	87/04/21	58.4 ± 7.14	0.275 ± 0.02	0.249 ± .031	23	0.47	0.90
	87/04/21	68.6 ± 12.8	0.508 ± .15	0.261 ± .04	23	0.74	0.51

Cont.

Table 3 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	WL (Rn) x10^{2} / [^{222}Rn]	WL(Tn) / WL(Rn)
99400	86/12/12	0.92 ± .77	0.007 ± 0.01	0.027 ± 0.01	23	0.76	3.86
	86/12/12	2.73 ± 3.75		0.02 ± 0.014	24		
	87/05/25	2.78 ± 0.92	0.004 ± 0.01	0.01 ± .01	23	0.14	2.50
53951	87/06/08	27.51 ± 1.71	0.078 ± .004	0.125 ± .005	24	0.28	1.60
	87/06/10	17.07 ± 2.8	0.05 ± .01	0.087 ± .012	24	0.29	1.74
	87/06/10	21.11 ± .148	0.07 ± .01	0.115 ± .007	23	0.33	1.64
	87/06/17	27.66 ± .69	0.075 ± .007	0.10	26	0.27	1.33
	87/06/17	23.92	0.07	0.07	24	0.29	1.00
53004	87/06/17	22.28 ± 2.2	0.08	0.097 ± .03	24	0.36	1.21
	87/06/17	31.39 ± 3.5	0.09	0.097 ± .07	16	0.29	1.08
50966	87/01/27	34.04 ± 3.8	0.105 ± .015	0.200 ± .05	0	0.31	1.90
	87/03/11	37.37 ± 2.7	0.230	0.180 ± .03	23	0.61	0.78
	87/05/13	40.13 ± 13.4	0.14 ± .005	0.17 ± 0.04	23	0.35	1.21
	87/05/13	30.12 ± 23.5	0.15 ± .011	0.18 ± .021	21	0.50	1.20
	87/05/13	38.20	0.14	0.16	13	0.37	1.14
	87/05/13	51.12	0.16	0.15	11	0.31	0.94
59882	87/04/07	10.51 ± 2.7	0.01 ± .007	0.054 ± .017	17	0.09	5.40
	87/04/07	5.53	0.01	0.05	24	0.18	5.00
59852	87/04/07	12.09 ± 1.67	0.02	0.04 ± 0.01	24	0.16	2.00
	87/04/07	17.72 ± 11.3	0.023 ± 0.01	0.073 ± .015	26	0.13	3.17
53007	87/06/09	16.6 ± .73	0.06	0.095 ± .02	23	0.36	1.58
	87/06/09	17.2	0.06	0.07	24	0.35	1.17
	87/06/09	18.09 ± 2.1	0.043 ± .01	0.07	13	0.24	1.63
57852	86/12/17	7.52 _ 2.1	0.015 ± .01	0.08 ± .03	23	0.20	5.33
	86/12/17	13.73 ± 8.9	0.02	0.065 ± .04	24	0.15	3.25

NOTE: Values given are daily average values.

TABLE 4

Radon Concentration, Radon progeny, Thoron progeny and mining activity

for several underground locations

Location	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	WL(Rn)x10^{3} [^{222}Rn]	WL(Tn) WL(Rn)
26680	5.83 ± 3.56	0.0144 ± .014	0.053 ± .023	21	0.25	3.68
38068	43.7 ± 3.295	0.0875 ± .001	0.109 ± .024	16	0.20	1.24
	37.11 ± 8.73	0.066 ± .023	0.08 ± .014	23	0.18	1.21
	64.87 ± 19.74	0.104 ± .03	0.09 ± 0.014	12	0.16	0.86
	24.76	0.037	0.071	13	0.15	1.92
38070	24.76	0.035	0.070	13	0.14	2.00
	41.37	0.087	0.092	16	0.21	1.01
38954	14.51 ± 5.53	0.025 ± .004	0.0575 ± .006	23	0.17	2.30
	22.23	0.02	0.11	11	0.09	5.50
38952	86.71 ± 3.64	0.415 ± 0.039	0.422 ± .089	21	0.48	1.02
38071	31.77 ± 9.4	0.034 ± .005	0.059 ± .027	13	0.11	1.73
	10.49	0.035	0.025	23	0.33	0.71
38062	61.6	0.300	0.010	23	0.49	0.03
	74.74	0.335	0.205	11	0.45	0.61
43951	148.76	0.76	0.41	31	0.51	0.54
49683	10.64 ± 6.15	0.021 ± .03	0.058 ± .016	21	0.20	2.76
	9.72	0.005	0.056	14	0.05	11.20
	6.88	0.010	0.060	17	0.14	6.00
49663	9.28	0.018	0.05	12	0.19	2.78
	10.2 ± 4.56	0.0217 ± .01	0.038 ± .023	23	0.21	1.75
	9.99	0.023	0.053	17	0.23	2.30
	39.44	0.220	0.135		0.56	0.61
45983	199.0 ± 30.8	1.64 ± .17	0.694 ± .115	24	0.82	0.42
	150.8 ± 28.7	1.36 ± .30	0.34 ± .17	23	0.85	0.29
40143	2130.27	10.34	0.15		0.48	0.01
40144	9.97	0.07	N/A	21	0.22	
	155.5 ± 115.8	0.69 ± .79	N/A	0	0.44	

Cont.

Table 4 - cont.

Location	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	WL(Rn) x10^{2} / [^{222}Rn]	WL(Tn) / WL(Rn)
52954	28.18	0.049	0.142	0	0.17	2.90
	35.03 ± 1.27	0.1205 ± .047	0.134 ± .04	24	0.34	1.11
	26.2 ± 2.9	0.05	0.103 ± .02	26	0.19	2.06
	24.7 ± 4.6	0.068 ± 0.02	n/a	21	0.27	-
52984	12.21	0.006	0.091	21	0.05	15.17
	23.3	0.041	0.132	23	0.18	3.22
52113	28.64	0.039	0.199	26	0.14	5.10
	30.54	0.063	0.148	0	0.21	2.35
	53.27	0.210	0.170	25	0.39	0.81
50106	48.49 ± 10.1	0.172 ± .04	0.199 ± .03	0	0.35	1.16
	43.62	0.121	0.24	12	0.27	2.00
	44.03	0.167	0.22	24	0.38	1.32
CR. Dec	11.15 ± 3.32	0.031 ± .01	0.071 ± .01	24	0.28	2.48
	9.39	0.033	0.097	23	0.35	2.94
NWR U/G	1.99	0	0.01	21	-	-
	4.88	0.01	0.03	42	0.20	3.00
98100	62.94 ± 20.7	0.482 ± .3	0.379 ± .09	21	0.77	0.79
	60.69 ± 11.2	0.371 ± .14	0.247 ± .03	23	0.61	0.66
99400	1.85 ± 1.30	0.006 ± .002	0.019 ± .012	23	0.32	3.17
	2.73 ± 3.75	0	0.02 ± .014	24	-	-
53951	22.8 ± 5.3	0.066 ± .014	0.094 ± .028	24	0.29	1.42
	21.11	0.07	0.155	23	0.33	2.21
	27.66	0.075	0.10	26	0.27	1.33
53004	22.28 ± 2.2	0.08	0.097 ± .03	24	0.36	1.21
	31.39 ± 3.5	0.09	0.097 ± .01	16	0.29	1.08
50966	34.04	0.105	0.200	0	0.31	1.90
	38.75 ± 1.95	0.185 ± .06	0.175 ± .007	23	0.48	0.95
	30.12	0.15	0.18	21	0.50	1.20
	38.20	0.14	0.16	13	0.37	1.14
	51.12	0.16	0.15	11	0.31	0.94
59882	10.51	0.01	0.054	17	0.10	5.40
	5.53	0.01	0.05	24	0.18	5.00

Cont.

Table 4 - cont.

Location	[^{222}Rn] (pCi/L)	WL (Rn)	WL (Tn)	Mining Activity	$\frac{WL(Rn) \times 10^2}{[^{222}Rn]}$	$\frac{WL(Tn)}{WL(Rn)}$
59852	12.09	0.02	0.04	24	0.16	2.00
	17.72	0.023	0.073	26	0.13	3.17
53007	16.6	0.06	0.09[5]	23	0.36	1.58
	17.2	0.06	0.07	24	0.35	1.17
	18.09	0.043	0.07	13	0.24	1.63
57852	7.52	0.015	0.08	23	0.20	5.33
	13.73	0.02	0.065	24	0.15	3.25

NOTE: a) Values given are average values.

b) Ratios (WL(RW)/[^{222}Rn]) x 10^2 and (WL(TN)/WL(Rn) are calculated with the average values of the corresponding variables in the ratios.

TABLE 5

Thoron and Thoron progeny concentration

for two underground mine locations and several sampling stations

Date YY/MM/DD	Location	[^{222}Rn] pCi/L (Bq/m^3)	WL(Tn) WL (μJ/m^3)	Q m^3/s	Remarks
87/11/16	38952	194.4 (7193)	0.462 (9.61)	-	
		192.1 (7108)	0.454 (9.44)	-	
		203.6 (7533)	0.482 (10.03)	-	
87/11/19	38952	217.1 (8033)	0.473 (9.84)	-	
		222.4 (8229)	0.490 (10.19)	-	
		202.9 (7507)	0.504 (10.48)	-	
87/12/17	38952	209.4 (7748)	0.458 (9.53)	-	
		236.7 (8758)	0.458 (9.53)	-	
		225.4 (8340)	0.455 (9.46)	-	
87/11/04	52984	82.5 (3053)	0.081 (1.68)	37.8	
		67.1 (2483)	0.074 (1.54)	37.8	
		75.1 (2779)	0.091 (1.89)	37.8	
87/12/30	52984	39.1 (1447)	0.101 (2.10)	23.6	
		32.2 (1191)	0.110 (2.29)	23.6	
		28.5(1055)	0.106 (2.20)	23.6	
88/01/07	52984	43.8 (1621)	0.063 (1.31)	20.3	
		42.0 (1554)	0.065 (1.35)	20.3	
		37.5 (1388)	0.061 (1.27)	20.3	
88/01/26	38952	191.8 (7097)	0.439 (9.13)	63.5	A
		251.6 (9309)	0.482 (10.03)	62.7	B
		197.2 (7296)	0.437 (9.09)	64.5	A
		167.0 (6179)	0.459 (9.54)	58.8	B
88/01/27	38952	230.6 (8532)	0.419 (8.72)	62.5	A
		245.2 (9072)	0.456 (9.48)	63.7	B
		217.7 (8055)	0.428 (8.90)	66.4	A
		163.0 (6031)	0.444 (9.23)	60.7	B
88/01/28	52984	65.4 (2420)	0.083 (1.73)	17.0	C
		224.0 ?	0.095 (1.97)	16.3	D
		51.8 (1917)	0.074 (1.54)	14.5	C
		59.7 (2209)	0.089 (1.85)	17.1	D
88/01/29	52984	70.4 (2605)	0.089 (1.85)	17.0	C
		45.7 (1691)	0.132 (2.75)	14.8	D
		46.7 (1728)	0.110 (2.29)	12.5	C
		43.0 (1591)	0.152 (3.16)	14.4	D

Note: The letters A, B, C and D refer to sampling stations.

TABLE 6

Radon gas flux measurements at several stations
in two underground mine locations by the fluxmeter can method

Location	Date YY/MM/DD	Flux Can #	$\overline{J}$ (pCi m^{-2} s^{-1})	$\overline{J}$ (pCi m^{-2} s^{-1})	$\overline{J}$ (mBq m^{-2} s^{-1})
52984	87/11/04	1	0.63		
	87/12/30	1	0.73	0.72	26.6
	88/01/07	1	0.79		
	87/11/04	2	0.19		
	87/12/30	2	0.17	0.18	6.7
	88/01/07	2	0.18		
	87/11/04	3	1.87		
	87/12/30	3	2.08	2.03	75.1
	88/01/07	3	2.14		
	87/11/04	4	2.13		
	87/12/30	4	2.22	2.23	82.5
	88/01/07	4	2.34		
	87/11/04	5	3.59		
	87/12/30	5	2.48	2.81	104.0
	88/01/07	5	2.36		
	87/11/04	6	1.26		
	87/12/30	6	1.35	1.36	50.3
	88/01/07	6	1.46		
38952	87/11/16	11	0.26		
	87/11/19	11	0.30	0.23	8.5
	87/12/17	11	0.12		
	87/11/16	12	0.10		
	87/11/19	12	0.11	0.12	4.4
	87/12/17	12	0.14		
	87/11/16	13	0.23		
	87/11/19	13	0.24	0.22	8.1
	87/12/17	13	0.20		
	87/11/16	14	0.05		
	87/11/19	14	0.06	0.05	1.8
	87/12/17	14	0.04		
	87/11/16	15	0.06		
	87/11/19	15	0.06	0.07	2.6
	87/12/17	15	0.07		
	87/11/16	16	0.18		
	87/11/19	16	0.16	0.18	6.7
	87/12/17	16	0.20		

Table 7 - Radiation data and other data at several mine stations.

DATE	STATION NUMBER	FORE STATION NUMBER	FORE STATION DISTANCE (m)	AVERAGE HEIGHT (m)	AVERAGE WIDTH (m)	AVERAGE CSA (m2)	AVERAGE Q (m3/s)	AVERAGE VELOCITY (m/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	RADON GAS FORE STATION (pCi/l)	THORON FORE STATION (w.l.)	RADON FORE STATION (w.l.)	RADON GAS STATION (pCi/l)	THORON STATION (w.l.)	RADON STATION (w.l.)	RADON FLUX	EMANATION CODE	MINING CODE
04-May-87	101.00	102.00	812.50	6.71	6.71	44.99	188.77	4.20	21796.78	36552.83	193.64	6.68	0.01	0.02	3.00	0.00	0.01	1.18	1.00	11.00
11-Dec-86	103.00	104.00	487.80	7.62	7.62	58.09	206.30	3.55	14872.10	28338.61	137.37	8.46	0.01	0.00	0.89	0.02	0.00	3.89	1.00	21.00
04-Jun-87	103.00	104.00	487.80	7.62	7.62	58.09	212.36	3.66	14872.10	28338.61	133.45	2.72	0.02	0.00	2.66	0.01	0.00	0.03	1.00	21.00
12-Dec-86	202.00	201.00	312.50	5.34	4.88	26.03	15.84	0.61	6383.38	8133.18	513.46	0.93	0.03	0.00	2.12	0.02	0.00	-0.11	3.00	24.00
01-Apr-87	202.00	201.00	312.50	5.34	4.88	26.03	18.88	0.73	6383.38	8133.18	430.78	4.24	0.02	0.00	2.98	0.01	0.00	0.14	3.00	23.00
25-May-87	202.00	201.00	312.50	5.34	4.88	26.03	24.07	0.92	6383.38	8133.18	337.90	2.63	0.01	0.00	2.43	0.00	0.00	0.03	3.00	23.00
29-Dec-86	203.00	204.00	85.37	3.66	4.27	15.62	19.89	1.27	1353.36	1333.05	67.02	47.91	0.34	0.27	48.62	0.28	0.26	-0.39	3.00	21.00
25-Mar-87	203.00	204.00	85.37	3.66	4.27	15.62	24.24	1.55	1353.36	1333.05	54.99	46.23	0.19	0.23	49.30	0.23	0.22	-2.03	3.00	21.00
21-Apr-87	203.00	204.00	85.37	3.66	4.27	15.62	17.69	1.13	1353.36	1333.05	75.36	53.75	0.24	0.29	63.02	0.25	0.26	-4.48	3.00	21.00
05-Jan-87	205.00	206.00	293.60	4.22	5.23	22.08	6.13	0.28	5549.63	6481.97	1057.42	106.81	0.58	1.09	48.44	0.31	0.30	2.39	3.00	21.00
26-Mar-87	205.00	206.00	293.60	4.22	5.23	22.08	4.96	0.22	5549.63	6481.97	1306.85	74.47	0.28	0.61	65.54	0.26	0.34	0.30	3.00	21.00
22-Apr-87	205.00	206.00	293.60	4.22	5.23	22.08	1.89	0.09	5549.63	6481.97	3429.61	77.38	0.25	0.65	59.81	0.27	0.37	0.22	3.00	21.00
15-Jan-87	208.00	207.00	76.83	3.66	3.93	14.38	54.73	3.81	1165.97	1104.53	20.18	8.92	0.09	0.03	12.33	0.08	0.04	-5.92	3.00	24.00
09-Apr-87	208.00	207.00	76.83	3.66	3.93	14.38	67.40	4.69	1165.97	1104.53	16.39	16.23	0.05	0.04	15.14	0.07	0.06	2.33	3.00	23.00
27-May-87	208.00	207.00	76.83	3.66	3.93	14.38	63.87	4.44	1165.97	1104.53	17.29	45.24	0.00	0.19	40.09	0.00	0.19	10.44	3.00	23.00
30-Dec-86	209.00	210.00	54.57	3.66	3.95	14.46	22.79	1.58	830.61	788.95	34.62	11.12	0.03	0.01	6.62	0.02	0.00	4.57	3.00	23.00
24-Mar-87	209.00	210.00	54.57	3.66	1.61	5.88	21.71	3.69	574.81	321.02	14.79	24.45	0.08	0.06	8.44	0.03	0.02	22.37	3.00	23.00
30-Mar-87	209.00	209.10	32.01	3.66	4.00	14.62	25.77	1.76	490.04	467.93	18.16	7.61	0.11	0.02	9.21	0.05	0.03	-3.11	3.00	23.00
27-Apr-87	209.00	209.10	32.01	3.66	4.00	14.62	23.41	1.60	490.04	467.93	19.99	5.55	0.02	0.01	3.37	0.02	0.01	3.85	3.00	23.00
28-Apr-87	209.00	209.10	32.01	3.66	4.00	14.62	23.50	1.61	490.04	467.93	19.91	6.45	0.04	0.02	8.02	0.04	0.02	-2.79	3.00	23.00
30-Mar-87	209.10	210.00	22.56	3.66	3.89	14.23	25.77	1.81	340.57	321.02	12.46	17.13	0.09	0.05	7.61	0.11	0.02	26.65	3.00	23.00
27-Apr-87	209.10	210.00	22.56	3.66	3.89	14.23	23.41	1.65	340.57	321.02	13.71	5.71	0.05	0.06	5.55	0.02	0.01	0.41	3.00	23.00
28-Apr-87	209.10	210.00	22.56	3.66	3.89	14.23	23.50	1.65	340.57	321.02	13.66	19.10	0.08	0.05	6.45	0.04	0.02	32.30	3.00	23.00
28-Apr-87	210.00	211.00	28.35	4.12	5.77	23.75	23.50	0.99	560.59	673.33	28.65	12.15	0.07	0.03	19.10	0.08	0.05	-10.78	3.00	23.00
22-Dec-86	301.00	302.00	115.55	3.05	6.19	18.88	9.44	0.50	2135.45	2181.22	231.06	4.34	0.10	0.00	1.11	0.00	0.00	0.53	2.00	21.00
09-Mar-87	301.00	302.00	115.55	3.05	6.19	18.88	9.56	0.51	2135.45	2181.22	228.16	5.41	0.05	0.02	5.21	0.03	0.01	0.03	2.00	21.00
29-Apr-87	301.00	302.00	115.55	3.05	6.19	18.88	8.73	0.46	2135.45	2181.22	249.85	3.68	0.05	0.01	1.15	0.04	0.01	0.38	2.00	21.00
01-Jun-87	301.00	302.00	115.55	3.05	6.19	18.88	4.72	0.25	2135.45	2181.22	462.12	10.76	0.05	0.03	9.24	0.02	0.04	0.12	2.00	21.00
23-Mar-87	303.00	305.30	101.22	3.20	4.86	15.57	13.57	0.87	1632.58	1575.85	116.13	6.88	0.06	0.01	5.69	0.04	0.00	0.37	7.00	17.00
23-Mar-87	303.00	308.00	385.37	3.20	6.99	22.36	19.23	0.86	7850.98	8617.20	448.11	19.85	0.03	0.02	5.69	0.04	0.00	1.28	7.00	17.00
14-Apr-87	303.00	308.00	385.37	3.20	1.28	4.09	18.16	4.44	3451.81	1575.85	86.78	14.24	0.07	0.02	9.85	0.03	0.01	0.85	7.00	23.00
23-Mar-87	305.30	306.10	164.63	3.20	7.02	22.47	16.75	0.75	3365.18	3699.21	220.85	10.56	0.06	0.02	6.88	0.06	0.01	0.68	7.00	17.00
29-Jan-87	307.00	306.10	164.63	3.20	7.02	22.47	8.97	0.40	3365.18	3699.21	412.40	9.95	0.05	0.02	5.26	0.03	0.01	0.46	7.00	12.00
12-Mar-87	402.00	401.00	52.74	5.63	6.58	37.02	4.11	0.11	1287.71	1952.83	475.14	217.70	0.51	2.06	189.58	0.12	2.32	3.32	2.00	23.00
14-May-87	402.00	401.00	52.74	5.63	6.58	37.02	4.11	0.11	1287.71	1952.83	475.14	148.75	0.46	1.12	154.51	0.19	1.23	-0.68	2.00	23.00

Cont.

DATE	STATION NUMBER	FORE STATION NUMBER	FORE STATION DISTANCE (m)	AVERAGE HEIGHT (m)	AVERAGE WIDTH (m)	AVERAGE CSA (m2)	AVERAGE Q (m3/s)	AVERAGE VELOCITY (m/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	RADON GAS FORE STATION (pCi/l)	THORON FORE STATION (w.l.)	RADON FORE STATION (w.l.)	RADON GAS STATION (pCi/l)	THORON STATION (w.l.)	RADON STATION (w.l.)	RADON FLUX	EXHAUSTION CODE	MINING CODE
12-Mar-87	403.00	402.00	47.26	5.75	6.59	37.85	4.11	0.11	1165.55	1788.44	435.14	217.70	0.51	2.06	151.80	0.40	1.55	8.60	2.00	23.00
14-May-87	403.00	402.00	47.26	5.75	6.59	37.85	4.11	0.11	1165.55	1788.44	435.14	148.75	0.46	1.12	88.00	0.43	0.65	7.92	2.00	23.00
23-Dec-86	404.00	401.00	137.50	5.81	7.34	42.63	4.72	0.11	3615.51	5861.16	1241.77	221.55	0.77	1.80	176.48	0.62	1.48	2.18	2.00	23.00
14-May-87	404.00	401.00	137.50	5.81	7.34	42.63	4.11	0.10	3615.51	5861.16	1426.07	154.51	0.19	1.23	101.16	..26	0.58	2.24	2.00	23.00
12-Mar-87	404.00	403.00	37.50	5.93	6.58	39.04	4.11	0.11	938.49	1463.95	356.19	151.80	0.40	1.55	175.90	0.30	1.65	-3.91	2.00	23.00
14-May-87	404.00	403.00	37.50	5.93	6.58	39.04	4.11	0.11	938.49	1463.95	356.19	88.00	0.43	0.65	101.16	0.26	0.58	-2.12	2.00	23.00
18-Mar-87	405.00	405.10	18.60	2.74	7.76	21.28	0.46	0.02	390.58	395.83	860.51	399.00	0.98	2.70	56.73	0.16	0.33	14.91	5.00	0.00
18-Mar-87	406.00	406.10	29.88	2.74	6.82	18.71	0.46	0.02	571.46	559.06	1215.36	308.04	0.96	2.72	180.27	0.48	1.72	3.81	5.00	0.00
08-Apr-87	408.00	409.00	31.40	3.66	4.31	15.77	17.59	1.12	500.45	495.13	28.15	46.19	0.11	0.08	34.27	0.08	0.07	15.50	2.00	23.00
08-Apr-87	408.00	410.00	71.34	3.66	4.46	16.32	17.59	1.08	1158.54	1164.38	66.20	40.62	0.11	0.09	34.27	0.08	0.07	3.57	2.00	23.00
12-May-87	408.00	410.00	71.34	3.66	4.46	16.32	15.80	0.97	1158.54	1164.38	73.69	38.60	0.03	0.08	31.15	0.03	0.06	3.76	2.00	23.00
12-May-87	408.00	409.00	31.40	3.66	4.31	15.77	15.80	1.00	500.45	495.13	31.34	34.67	0.14	0.10	31.15	0.03	0.06	4.11	2.00	23.00
12-May-87	409.00	410.00	39.94	3.66	4.58	16.76	15.80	0.94	658.09	669.24	42.36	38.60	0.03	0.08	34.67	0.14	0.10	3.49	2.00	23.00
10-Jun-87	412.00	413.00	105.79	3.81	4.51	17.20	47.19	2.74	1761.14	1819.34	38.55	17.51	0.08	0.05	16.38	0.10	0.06	1.12	2.00	24.00
10-Jun-87	412.00	416.00	183.84	3.81	4.34	16.52	47.19	2.86	2995.52	3037.90	64.38	21.11	0.11	0.07	16.38	0.10	0.06	2.76	2.00	24.00
10-Jun-87	413.00	416.00	78.05	3.81	4.10	15.61	47.19	3.02	1234.38	1218.56	25.82	21.11	0.11	0.07	17.51	0.08	0.05	5.09	2.00	24.00
08-Jun-87	415.00	416.00	51.52	3.93	3.18	12.46	50.97	4.09	731.68	642.15	12.60	27.84	0.13	0.08	27.18	0.12	0.08	1.70	2.00	24.00
10-Jun-87	415.00	416.00	51.52	3.93	3.18	12.46	47.19	3.79	731.68	642.15	13.61	21.11	0.11	0.07	16.74	0.08	0.05	10.43	2.00	24.00
09-Jun-87	417.00	417.10	30.49	3.05	4.34	13.24	4.78	0.36	450.62	403.54	84.42	17.45	0.09	0.05	16.79	0.09	0.07	0.26	4.10	13.00
17-Mar-87	501.00	502.00	293.29	3.20	6.67	21.37	61.35	2.87	5792.87	6266.52	102.14	11.15	0.06	0.01	4.44	0.06	0.00	2.63	2.00	24.00
17-Dec-86	504.00	507.00	304.27	3.43	6.51	22.33	37.75	1.69	6048.76	6793.83	179.97	13.74	0.07	0.02	7.52	0.08	0.01	1.44	2.00	24.00
17-Mar-87	504.00	505.00	111.59	3.37	6.64	22.35	61.35	2.74	2232.73	2494.49	40.66	14.92	0.10	0.02	11.43	0.06	0.03	3.55	2.00	24.00
17-Mar-87	504.00	506.00	212.50	3.48	7.11	24.72	61.35	2.48	4499.89	5252.96	85.62	12.30	0.11	0.02	7.52	0.08	0.01	2.41	2.00	24.00
17-Mar-87	505.00	506.00	100.91	3.55	7.64	27.13	61.35	2.26	2258.73	2738.22	44.63	12.30	0.11	0.02	14.92	0.10	0.02	-2.63	2.00	24.00
07-Apr-87	508.00	509.00	209.63	3.47	6.71	23.26	31.89	1.37	5894.23	6737.15	211.26	9.82	0.06	0.04	9.53	0.05	0.01	0.06	2.00	24.00
07-Apr-87	510.00	511.00	266.77	3.57	6.40	22.89	31.89	1.39	5323.17	6105.46	191.45	17.72	0.07	0.02	12.10	0.04	0.02	1.25	2.00	24.00
04-Dec-86	601.00	602.00	170.73	3.51	8.10	28.39	39.01	1.37	3962.11	4847.02	124.25	10.70	0.05	0.00	10.09	0.06	0.00	0.22	2.00	21.00
04-Mar-87	601.00	602.10	98.17	3.89	22.53	87.58	35.51	0.41	5186.74	8597.54	242.12	11.28	0.03	0.01	11.66	0.04	0.01	-0.10	2.00	21.00

Cont.

Table 7 - cont.

DATE	STATION NUMBER	FORE STATION NUMBER	FORE STATION DISTANCE (m)	AVERAGE HEIGHT (m)	AVERAGE WIDTH (m)	AVERAGE CSA (m2)	AVERAGE Q (m3/s)	AVERAGE VELOCITY (m/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	RADON GAS FORE STATION (pCi/l)	THORON FORE STATION (w.l.)	RADON FORE STATION (w.l.)	RADON GAS STATION (pCi/l)	THORON STATION (w.l.)	RADON STATION (w.l.)	RADON FLUX	EMANATION CODE	MIXING CODE
20-Apr-87	601.00	602.10	98.17	3.89	22.53	87.58	37.16	0.42	5186.74	8597.54	231.37	12.90	0.11	0.02	11.97	0.03	0.02	0.25	2.00	21.00
04-Mar-87	601.00	602.20	125.61	3.89	19.15	74.42	35.51	0.48	5786.36	9348.36	263.26	14.95	0.04	0.01	11.66	0.04	0.01	0.75	2.00	21.00
20-Apr-87	601.00	602.20	125.61	3.89	19.15	74.42	37.16	0.50	5786.36	9348.36	251.57	16.23	0.10	0.02	11.97	0.03	0.02	1.01	2.00	21.00
04-Dec-86	601.00	603.00	318.60	3.89	8.24	32.04	39.01	1.22	7728.98	10207.93	261.67	14.70	0.13	0.01	10.09	0.06	0.00	0.86	2.00	21.00
04-Mar-87	601.00	603.00	318.60	3.89	8.24	32.04	35.51	1.11	7728.98	10207.93	287.47	25.10	0.08	0.01	11.66	0.04	0.01	2.28	2.00	21.00
20-Apr-87	601.00	603.00	318.60	3.89	8.24	32.04	37.16	1.16	7728.98	10207.93	274.70	19.93	0.11	0.03	11.97	0.03	0.02	1.42	2.00	21.00
04-Dec-86	602.00	603.00	147.87	4.27	8.41	35.90	39.01	1.09	3749.44	5307.99	136.07	14.70	0.13	0.01	10.70	0.05	0.00	1.54	2.00	21.00
04-Mar-87	602.10	602.20	27.44	4.27	7.04	30.05	35.51	1.18	620.54	824.43	23.22	14.95	0.04	0.01	11.20	0.03	0.01	7.77	2.00	21.00
20-Apr-87	602.10	602.20	27.44	4.27	7.04	30.05	37.16	1.24	620.54	824.43	22.19	16.23	0.10	0.02	12.90	0.11	0.02	7.38	2.00	21.00
04-Mar-87	602.10	603.00	49.70	4.27	7.16	30.58	35.51	1.16	1136.23	1519.52	42.79	25.10	0.08	0.01	11.20	0.03	0.01	15.98	2.00	21.00
20-Apr-87	602.10	603.00	49.70	4.27	7.16	30.58	37.16	1.22	1136.23	1519.52	40.89	19.93	0.11	0.03	12.90	0.11	0.02	8.51	2.00	21.00
04-Mar-87	602.20	603.00	22.26	4.27	7.32	31.23	35.51	1.14	515.69	695.09	19.57	25.10	0.08	0.01	14.95	0.04	0.01	25.86	2.00	21.00
20-Apr-87	602.20	603.00	22.26	4.27	7.32	31.23	37.16	1.19	515.69	695.09	18.71	19.93	0.11	0.03	16.23	0.10	0.02	9.86	2.00	21.00
16-Dec-86	603.00	604.00	68.60	4.27	10.78	46.01	13.21	0.29	2064.62	3156.47	238.95	18.72	0.15	0.02	22.90	0.16	0.02	-0.99	7.00	23.00
15-Dec-86	603.00	605.10	59.45	3.73	11.62	43.40	13.63	0.31	1825.88	2580.35	189.31	27.39	0.12	0.06	25.42	0.12	0.02	0.54	7.00	23.00
10-Dec-86	604.00	606.10	48.78	4.49	16.06	72.16	16.52	0.23	2005.02	3520.05	213.08	22.62	0.12	0.03	18.72	0.15	0.02	1.19	7.00	13.00
16-Dec-86	604.00	606.10	48.78	4.49	16.06	72.16	13.21	0.18	2005.02	3520.05	266.47	27.02	0.10	0.05	26.60	0.13	0.04	0.10	7.00	23.00
26-Jan-87	604.00	606.10	48.78	4.49	16.06	72.16	13.52	0.19	2005.02	3520.05	260.36	30.89	0.14	0.06	19.17	0.16	0.03	2.92	7.00	11.00
30-Apr-87	607.00	608.00	54.88	3.39	11.05	37.49	33.51	0.89	1585.27	2057.12	61.39	24.00	0.07	0.05	23.69	0.07	0.04	0.24	2.00	24.00
13-Apr-87	607.00	609.10	106.71	3.21	8.88	28.49	33.51	1.18	2579.33	3039.61	90.71	53.27	0.17	0.21	24.66	0.09	0.06	13.75	4.20	25.00
09-Dec-86	607.00	610.00	40.85	3.57	10.27	36.67	35.92	0.98	1130.86	1497.95	41.70	22.01	0.13	0.05	20.07	0.11	0.03	2.28	2.00	23.00
13-Apr-87	607.00	610.00	40.85	3.57	10.27	36.67	34.92	0.95	1130.86	1497.95	42.90	36.57	0.10	0.11	24.66	0.09	0.06	13.61	2.00	24.00
09-Dec-86	607.00	611.00	164.02	3.57	16.81	60.03	35.92	0.60	6687.24	9846.51	274.12	27.81	0.15	0.05	20.07	0.11	0.03	1.54	2.00	23.00
30-Apr-87	607.00	611.00	278.96	3.57	8.66	30.93	33.51	1.08	6824.74	8626.98	257.44	43.02	0.25	0.21	23.69	0.07	0.04	3.51	2.00	24.00
08-Dec-86	608.00	609.10	51.83	3.17	6.57	20.85	13.21	0.63	1010.19	1080.45	81.79	25.11	0.14	0.03	20.88	0.14	0.03	2.05	4.20	26.00
19-Jan-87	608.00	609.10	51.83	3.17	6.57	20.85	12.74	0.61	1010.19	1080.45	84.81	26.63	0.15	0.07	28.32	0.13	0.06	-0.79	4.20	23.00
30-Apr-87	608.00	611.00	224.09	3.57	8.08	28.84	33.51	1.16	5219.89	6461.69	192.83	43.02	0.25	0.21	24.00	0.07	0.05	4.52	2.00	24.00
02-Jun-87	608.00	611.00	224.09	3.57	8.08	28.84	46.25	1.60	5219.89	6461.69	139.71	45.78	0.36	0.20	25.84	0.14	0.07	6.54	2.00	24.00
09-Dec-86	610.00	611.00	123.17	3.71	11.29	41.88	35.92	0.86	3694.73	5158.73	143.62	27.81	0.15	0.05	22.01	0.13	0.05	2.09	2.00	23.00
20-Jan-87	613.00	615.10	119.51	3.13	13.70	42.82	9.67	0.23	4022.35	5117.80	529.25	46.28	0.20	0.16	36.27	0.16	0.12	0.89	4.20	23.00
21-Jan-87	613.00	614.10	119.51	3.13	13.94	43.53	11.80	0.27	4078.12	5204.94	441.10	46.06	0.09	0.17	40.48	0.18	0.12	0.60	4.20	12.00
11-Mar-87	613.00	616.00	195.12	3.20	10.07	32.25	46.48	1.44	5180.14	6291.81	135.37	37.37	0.18	0.23	36.26	0.17	0.18	0.37	2.00	24.00

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Table 7 - cont.

DATE	STATION NUMBER	FORE STATION NUMBER	FORE STATION DISTANCE (m)	AVERAGE HEIGHT (m)	AVERAGE WIDTH (m)	AVERAGE CSA (m2)	AVERAGE Q (m3/s)	AVERAGE VELOCITY (m/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	RADON GAS FORE STATION (pCi/l)	THORON FORE STATION (w.l.)	RADON FORE STATION (w.l.)	RADON GAS STATION (pCi/l)	THORON STATION (w.l.)	RADON STATION (w.l.)	RADON FLUX	EMANATION CODE	MINING CODE
11-Mar-87	613.10	613.00	59.45	3.05	9.25	28.20	47.19	1.67	1462.30	1676.51	35.53	36.38	0.17	0.19	36.14	0.17	0.16	0.29	2.00	23.00
06-May-87	614.00	615.10	119.51	3.13	13.94	43.55	10.01	0.23	4078.12	5204.94	519.97	47.70	0.23	0.22	44.04	0.22	0.17	0.33	4.20	24.00
21-May-87	617.00	617.10	30.79	3.66	4.54	16.61	13.71	0.83	504.91	511.46	37.31	16.57	0.13	0.02	16.50	0.12	0.02	0.07	7.00	23.00
20-May-87	618.00	618.10	26.83	3.51	7.37	25.85	16.52	0.64	583.73	693.50	41.98	18.56	0.08	0.03	16.27	0.11	0.02	2.40	7.00	15.00
13-May-87	620.00	614.10	231.71	3.66	6.71	24.54	84.79	3.46	4803.69	5685.86	67.06	22.64	0.10	0.14	50.87	0.16	0.15	-18.44	2.00	11.00
02-Jun-87	621.00	608.00	103.66	3.54	13.41	47.52	27.84	0.59	3514.37	4925.73	176.93	25.84	0.14	0.07	26.19	0.10	0.05	-0.10	2.00	26.00
02-Apr-87	701.00	702.10	85.37	2.90	2.67	7.72	7.39	0.96	949.58	659.04	89.18	25.73	0.08	0.03	8.36	0.06	0.02	5.00	4.10	13.00
06-Apr-87	701.00	702.10	85.37	2.90	2.67	7.72	7.08	0.92	949.58	659.04	93.09	27.72	0.04	0.04	10.21	0.01	0.03	4.83	4.10	13.00
10-Mar-87	701.00	703.00	54.88	3.51	4.23	14.85	18.88	1.27	869.57	814.73	43.15	22.23	0.11	0.02	10.63	0.05	0.03	9.54	2.00	11.00
08-Jan-87	703.00	704.10	79.27	2.90	7.88	22.82	11.33	0.50	1708.43	1809.14	159.68	41.37	0.09	0.09	24.76	0.07	0.04	4.08	4.10	16.00
06-Jan-87	705.00	706.10	45.73	2.90	6.11	17.71	9.44	0.53	824.10	809.80	85.78	48.29	0.13	0.08	44.05	0.13	0.08	1.80	4.10	16.00
12-Jan-87	705.00	706.10	45.73	2.90	6.11	17.71	9.20	0.52	824.10	809.80	88.02	49.80	0.08	0.09	29.88	0.07	0.04	8.23	4.10	12.00
14-Jan-87	705.00	706.10	45.73	2.90	6.11	17.71	6.13	0.35	824.10	809.80	132.11	66.60	0.08	0.09	39.84	0.09	0.08	7.36	4.10	12.00
14-Jan-87	705.00	707.00	22.56	3.35	6.46	21.67	25.96	1.20	442.82	488.78	18.83	43.58	0.09	0.08	39.84	0.09	0.08	8.11	2.00	23.00
18-Dec-86	801.00	802.00	155.49	3.73	6.80	25.39	76.92	3.03	3275.67	3948.11	51.33	98.26	0.57	0.45	83.31	0.48	0.41	12.99	2.00	23.00
05-Mar-87	801.00	802.00	155.49	3.73	6.80	25.39	70.50	2.78	3275.67	3948.11	56.00	91.39	0.37	0.38	79.03	0.36	0.35	9.84	2.00	23.00
05-May-87	801.00	802.00	155.49	3.73	6.80	25.39	80.13	3.16	3275.67	3948.11	49.27	84.46	0.36	0.45	83.03	0.39	0.44	1.29	2.00	23.00

Table 8 - Radon flux data by the 2 point measurement method, [^{222}Rn] and WL(Rn) experimental data and theoretical data for [^{222}Rn] and WL(Rn) using the VENT RAD mine model.

Location	Station	Date YY/MM/DD	J $Bqm^{-3}s^{-1}$	Initial Conditions [^{222}Rn] (Bqm^{-3})	Initial Conditions WL (Rn)	Observed Final Conditions [^{222}Rn] (Bqm^{-3})	Observed Final Conditions WL (Rn)	Calculated Final Conditions [^{222}Rn] (Bqm^{-3})	Calculated Final Conditions WL (Rn)	Remarks
52984	601.0 - 602.0	86/12/04	0.22	373.33	0.00	395.90	0.00	395.7	0.00	
	602.0 - 603.0		1.59	395.90	0.00	543.90	0.01	543.5	0.001	
	601.0 - 603.0		0.86	373.33	0.00	543.90	0.01	543.8	0.002	
	601.0 - 602.1	87/03/04	-0.07	431.40	0.01	417.36	0.01	431.4	0.017	
	601.0 - 602.2		0.56	431.40	0.01	553.15	0.01	552.2	0.020	
	601.0 - 603.0		2.35	431.40	0.01	928.70	0.01	928.7	0.024	
	602.1 - 602.2		7.53	417.36	0.01	553.15	0.01	553.0	0.011	
	602.1 - 603.0		16.88	417.36	0.01	928.70	0.01	928.5	0.012	
	602.2 - 603.0		26.29	553.15	0.01	928.70	0.01	928.7	0.011	
	601.0 - 602.1		0.20	442.89	0.02	477.30	0.02	477.0	0.027	
	601.0 - 602.2		0.79	442.89	0.02	600.51	0.02	601.1	0.029	
	601.0 - 603.0		1.47	442.89	0.02	737.41	0.03	738.3	0.031	
	602.1 - 602.2		7.12	477.30	0.02	600.51	0.02	600.5	0.021	
	602.1 - 603.0		8.75	477.30	0.02	737.41	0.03	737.4	0.022	
	602.2 - 603.0		9.40	600.51	0.02	737.41	0.03	737.5	0.021	
38952	801.0 - 802.0	86/12/18	12.98	3082.47	0.41	3635.62	0.45	3635.2	0.42	Exhaustway
	801.0 - 802.0	87/03/05	9.84	2924.11	0.35	3381.43	0.38	3381.3	0.36	
	801.0 - 802.0	87/05/05	2.86	3052.87	0.44	3169.05	0.44	3169.3	0.45	
47E Ramp	209.0 - 210.0	86/12/30	5.34	240.87	0.00	439.93	0.01	440.1	0.00	
	209.0 - 210.0	87/03/24	15.48	312.28	0.02	904.65	0.06	904.5	0.022	
	209.0 - 209.1	87/03/30	0.60	340.77	0.03	352.61	0.02	352.7	0.030	
	209.0 - 210.0		7.43	340.77	0.03	583.86	0.04	572.3	0.031	
	209.1 - 210.0		16.99	352.61	0.02	583.86	0.04	584.2	0.020	
	209.0 - 209.1	87/04/27	3.91	124.69	0.01	205.35	0.01	205.3	0.010	
	209.0 - 210.0		2.42	124.69	0.01	211.27	0.06	211.2	0.010	
	209.0 - 211.0		15.35	124.69	0.01	1132.57	0.07	1132.9	0.015	
	209.1 - 210.0		0.38	205.35	0.01	211.27	0.06	211.1	0.010	
	209.1 - 211.0		0.65	205.35	0.01	1132.57	0.07	233.0	0.011	

Cont.

Table 8 - cont.

Location	Station	Date YY/MM/DD	J Bqm^{-3}s^{-1}	Initial Conditions [^{222}Rn] (Bqm^{-3})	Initial Conditions WL (Rn)	Observed Final Conditions [^{222}Rn] (Bqm^{-3})	Observed Final Conditions WL (Rn)	Calculated Final Conditions [^{222}Rn] (Bqm^{-3})	Calculated Final Conditions WL (Rn)	Remarks
	210.0 - 211.0		36.97	211.27	0.06	1132.57	0.07	1132.9	0.059	
	209.0 - 209.1	87/04/28	-2.93	296.74	0.02	238.65	0.02	296.7	0.020	
	209.0 - 210.0		11.64	296.74	0.02	706.70	0.05	706.4	0.021	
	209.0 - 211.0		2.54	296.74	0.02	449.55	0.03	449.6	0.022	
	209.1 - 210.0		31.44	238.65	0.02	706.70	0.05	706.4	0.021	
	209.1 - 211.0		0.16	238.65	0.02	449.55	0.03	245.0	0.021	
	210.0 - 211.0		-10.18	706.70	0.05	449.55	0.03	706.7	0.051	

Table 9 - Thoron flux calculated according to several mine models (indicated at the top of the table).

(1) TEMN: $J = \frac{[Tn(2)-Tn(1)] \times \theta \times 1000}{S}$

(2) NTEMN: $J = \frac{[Tn(2) - Tn(1)] \times V \times \lambda \times 1000}{S \times (1 - e^{(-\lambda \times t)})}$

(3) BIGU: $J = \frac{[Tn(2) - Tn(1) \times e^{(-L \times t)}] \times L \times V \times 1000}{S \times (1 - e^{(-L \times t)})}$

(4) BIGU (Rn)=0 T=0: $J = \frac{[Tn(2) - Tn(1)] \times L \times V \times 1000}{S \times (1 - e^{(-L \times t)})}$

WHERE: Tn = 500 x WL(Tn) ; λ = (0.693 / 54.5) ; L = (0.693 / 54.5) + θ/V

DATE	LOCATION	STATION NUMBER	FORE STATION NUMBER	AIR FLOW	RUBBING SURFACE	VOLUME	RETENTION TIME	FORE STATION	STATION	DELTA WL(Tn)	DELTA WL(Tn) x500	J (1)	J (1)	DELTA WL(Tn) x500 x1000	J (2)	J (2)	J (3)	J (3)	J (4)	J (4)
				θ	S	V	t	WL(Tn)	WL(Tn)											
				(M3/S)	(M2)	(M3)	(S)	W.L.	W.L.		pCi/l	pCi/m2/s	Bq/m2/s	pCi/m3	pCi/m2/s	Bq/m2/s	pCi/m2/s	Bq/m2/s	pCi/m2/s	Bq/m2/s
04-Dec-86	52984		601.00	602.00	38.99	3962.11	4847.02	124.31	0.05	0.06	-0.01	-7.50	-73.81	-2.73	-7500.0	-146.906	-5.436	619.316	22.915	-206.082	-7.625
04-Dec-86	52984		601.00	603.00	38.99	7728.98	10207.93	261.79	0.13	0.06	0.06	31.25	157.66	5.83	31250.0	544.315	20.140	1401.346	51.850	691.582	25.589
04-Dec-86	52984		602.00	603.00	39.17	3636.74	4834.06	123.41	0.13	0.05	0.08	38.75	417.36	15.44	38750.0	827.160	30.605	1853.057	68.563	1161.247	42.966
04-Mar-87	52984		601.00	602.10	34.92	6630.63	8824.09	252.68	0.03	0.04	-0.01	-5.00	-26.33	-0.97	-5000.0	-88.157	-3.262	331.165	12.253	-112.611	-4.167
04-Mar-87	52984		601.00	602.20	33.51	7230.26	9574.91	285.76	0.04	0.04	0.00	1.67	7.72	0.29	1666.7	28.827	1.067	465.605	17.227	36.140	1.337
04-Mar-87	52984		601.00	603.00	36.57	7728.98	10207.93	279.10	0.08	0.04	0.04	20.00	94.64	3.50	20000.0	345.822	12.795	865.641	32.029	435.122	16.100
04-Mar-87	52984		602.10	602.20	34.45	620.54	824.43	23.93	0.04	0.03	0.01	6.67	370.11	13.69	6666.7	429.274	15.883	1748.670	64.701	662.517	24.513
04-Mar-87	52984		602.10	603.00	37.52	1136.23	1519.52	40.50	0.08	0.03	0.05	25.00	825.49	30.54	25000.0	1056.215	39.080	2353.323	87.073	1602.956	59.309
04-Mar-87	52984		602.20	603.00	36.10	515.69	695.09	19.25	0.08	0.04	0.04	18.33	1283.46	47.49	18333.3	1446.975	53.538	4132.076	152.887	2243.909	83.025
04-Mar-87	52984		601.00	602.10	38.93	6630.63	8824.09	226.65	0.11	0.03	0.08	38.33	225.08	8.33	38333.3	687.177	25.426	1272.045	47.066	892.149	33.009
04-Mar-87	52984		601.00	602.20	36.10	7230.26	9574.91	265.22	0.10	0.03	0.06	31.67	158.12	5.85	31666.7	552.180	20.431	1064.061	39.370	700.191	25.907
04-Mar-87	52984		601.00	603.00	38.46	7728.98	10207.93	265.41	0.11	0.03	0.07	36.67	182.46	6.75	36666.7	637.599	23.591	1171.256	43.336	808.419	29.912
04-Mar-87	52984		602.10	602.20	35.87	620.54	824.43	22.99	0.10	0.11	-0.01	-6.67	-385.32	-14.26	-6666.7	-444.372	-16.442	3421.561	126.598	-686.482	-25.400
04-Mar-87	52984		602.10	603.00	38.23	1136.23	1519.52	39.75	0.11	0.11	0.00	-1.67	-56.07	-2.07	-1666.7	-71.430	-2.643	2677.125	99.054	-108.487	-4.014
04-Mar-87	52984		602.20	603.00	35.39	515.69	695.09	19.64	0.11	0.10	0.01	5.00	343.17	12.70	5000.0	387.801	14.349	4746.866	175.634	601.148	22.242
18-Dec-86	38952		801.00	802.00	76.92	3275.67	3948.11	51.33	0.37	0.48	0.08	41.00	962.81	35.62	41000.0	1310.923	48.504	11359.946	420.318	1968.161	72.822
05-Mar-87	38952		801.00	802.00	70.50	3275.67	3948.11	56.00	0.37	0.36	0.01	4.00	86.10	3.19	4000.0	120.354	4.453	6886.509	254.801	179.864	6.655
05-May-87	38952		801.00	802.00	80.48	3275.67	3948.11	49.05	0.36	0.38	-0.02	-10.00	-245.70	-9.09	-10000.0	-330.246	-12.219	7163.103	265.035	-496.934	-18.387
30-Dec-86	47K	RAMP	209.00	210.00	22.26	830.61	788.95	35.44	0.05	0.05	0.00	2.50	67.00	2.48	2500.0	83.223	3.079	1001.663	37.062	126.948	4.697
24-Mar-87	47K	RAMP	209.00	210.00	21.71	830.61	788.95	36.34	0.08	0.03	0.05	25.42	664.28	24.58	25416.7	829.547	30.693	1773.747	65.629	1264.235	46.777
30-Mar-87	47K	RAMP	209.00	209.10	24.65	490.04	467.93	18.98	0.05	0.05	0.01	2.92	146.73	5.43	2916.7	165.152	6.111	1739.378	64.357	256.182	9.479
30-Mar-87	47K	RAMP	209.00	210.00	26.66	830.61	788.95	29.60	0.08	0.05	0.03	13.75	441.28	16.33	13750.0	529.514	19.592	1861.579	68.878	812.515	30.063
30-Mar-87	47K	RAMP	209.10	210.00	24.99	340.57	321.02	12.84	0.08	0.05	0.02	10.83	795.05	29.42	10833.3	861.742	31.884	3621.879	134.010	1345.206	49.773
27-Apr-87	47K	RAMP	209.00	209.10	23.77	490.04	467.93	19.68	0.02	0.02	0.00	0.00	0.00	0.00	0.0	0.000	0.000	707.638	26.183	0.000	0.000
27-Apr-87	47K	RAMP	209.00	210.00	23.24	830.61	788.95	33.94	0.05	0.02	0.02	11.67	326.46	12.08	11666.7	401.964	14.873	1081.447	40.014	614.082	22.721
27-Apr-87	47K	RAMP	209.00	211.00	22.71	1491.67	1676.51	73.82	0.10	0.02	0.08	38.33	583.64	21.59	38333.3	899.788	33.292	1666.012	61.642	1321.652	48.901
27-Apr-87	47K	RAMP	209.10	210.00	22.48	340.57	321.02	14.28	0.05	0.02	0.02	11.67	769.92	28.49	11666.7	841.947	31.152	2222.101	82.218	1312.353	48.557
27-Apr-87	47K	RAMP	209.10	211.00	22.42	952.84	1111.10	49.57	0.10	0.02	0.08	38.33	901.82	33.37	38333.3	1215.675	44.980	2275.800	84.205	1828.343	67.649
27-Apr-87	47K	RAMP	210.00	211.00	23.18	577.87	723.20	31.20	0.10	0.05	0.05	26.67	1069.81	39.58	26666.7	1295.980	47.951	3292.794	121.833	1985.396	73.460
28-Apr-87	47K	RAMP	209.00	209.10	24.78	490.04	467.93	18.89	0.04	0.04	0.00	0.00	0.00	0.00	0.0	0.000	0.000	1254.023	46.399	0.000	0.000
28-Apr-87	47K	RAMP	209.00	210.00	23.60	830.61	788.95	33.44	0.08	0.04	0.04	18.33	520.82	19.27	18333.3	639.352	23.656	1786.963	66.118	977.243	36.158
28-Apr-87	47K	RAMP	209.00	211.00	24.78	1491.67	1676.51	67.67	0.07	0.04	0.03	16.67	276.82	10.24	16666.7	412.789	15.273	1227.932	45.433	609.918	22.567
28-Apr-87	47K	RAMP	209.10	210.00	22.89	340.57	321.02	14.03	0.08	0.04	0.04	18.33	1232.10	45.59	18333.3	1345.228	49.773	3681.198	136.204	2097.381	77.603
28-Apr-87	47K	RAMP	209.10	211.00	24.07	952.84	1111.10	46.17	0.07	0.04	0.03	16.67	420.99	15.58	16666.7	556.571	20.593	1641.642	60.741	839.904	31.076
28-Apr-87	47K	RAMP	210.00	211.00	22.89	577.87	723.20	31.60	0.07	0.08	0.00	-1.67	-66.01	-2.44	-1666.7	-80.159	-2.966	2005.550	74.205	-122.751	-4.542

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TABLE 10

Flux Ratio, $J(^{220}Rn)/J(^{222}Rn)$, for several underground locations

Flux data obtained with MTMV using Eq.15

Date YY/MM/DD	Location	Stations	$J(^{222}Rn)$ ($Bqm^{-2}\ s^{-1}$)	$J(^{220}Rn)$ ($Bqm^{-2}\ s^{-1}$)	$J(^{220}Rn)/J^{222}Rn)$	Rt. (s)
87/05/04	NO. 2 Shaft	101, 102	2.83	5.73	2.0	193.6
86/12/11	NWR A/B	103, 104	6.60	6.57	1.0	137.4
87/06/04	NWR Top/UG	103, 104	1.46	14.76	10.1	133.5
87/04/01	Surf. Ramp	202, 201	0.54	7.09	13.1	430.8
87/05.25	99400		0.38	3.71	9.8	337.9
87/01/05	98100	205, 206	5.76	171.21	29.7	1057.4
87/03/26			2.64	81.56	30.9	1306.8
87/04/22			1.11	70.26	63.3	3429.6
87/03/30	47K	209.1, 210	63.47	131.10	2.1	12.5
87/04/27			14.76	94.70	6.4	13.7
87/04/28			67.56	146.70	2.2	13.7
87/03/30	47K	209, 209.1	13.00	161.36	12.4	18.2
87/04/27			12.05	22.17	1.89	20.0
87/04/28			9.82	44.47	4.45	19.9
87/04/08	95167	408, 410	24.90	59.83	2.4	66.2
87/05/12			21.67	14.66	0.7	73.7
87/03/04	52984	602.1, 603	38.33	83.54	2.2	42.8
87/04/20			29.07	101.16	3.5	40.9
86/12/23	45983	404, 401	11.99	312.24	26.0	1241.8
87/05/14			7.82	76.45	9.8	1426.1

Notes: 1.) RT stands for mine air residence time
2.) UG stands for Underground
3.) NWR indicates North West Reef

TABLE 11

Radiation, meteorological and climatic data for several locations and seasons

Location	Date YY/MM/DD	[^{222}Rn] pCi/L	WL (Rn)	WL (Tn)	RH %	T °C	P kPa	Q m³/s	Mining Activity
38952	86/12/18	90.8 ± 15.2	0.43 ± 0.03	0.52 ± 0.09	60.4 ± 9	13.7 ± 0.2	104.2 ± 0.2	76.9 ± 0.0	21
	87/03/05	85.6 ± 9.9	0.37 ± 0.02	0.37 ± 0.02	83.5 ± 0.4	12.5 ± 0.4	105.9 ± 0.2	70.0 ± 3.9	21
	87/05/05	83.7 ± 6.2	0.44 ± 0.02	0.37 ± 0.04	87.8 ± 1.6	12.8 ± 0.2	105.7 ± 0.1	80.1 ± 2.1	21
	87/07/30	188.2 _ 24.4	1.29 ± 0.03	-	-	-	-	-	-
	87/09/21	120.1 ± 23.4	0.41 ± 0.12	-	-	-	-	-	-
52984	86/12/04	12.1 ± 2.9	0.006 ± 0.007	0.09 ± 0.04	-	14.2 ± 1.4	105.9 ± 0.4	39.0 ± 0.5	21
	86/12/06	23.3 ± 6.0	0.04 ± 0.01	0.13 ± 0.03	64.3 ± 2.8	12.2 ± 0.5	106.3 ± 0.2	35.9 ± 1.4	23
	86/12/15	25.1 ± 5.6	0.03 ± 0.02	0.12 ± 0.03	-	17.6 ± 2.4	107.1 ± 0.1	19.8 ± 10.1	0
	87/03/04	15.7 ± 8.1	0.01 ± 0.00	0.05 ± 0.02	54.2 ± 4.1	8.6 ± 0.1	107.7 ± 0.3	35.5 ± 2.4	21
	87/04/20	15.3 ± 3.5	0.02 ± 0.01	0.09 ± 0.05	94.1 ± 2.3	12.5 ± 0.5	106.9 ± 0.4	37.2 ± 2.5	21
	87/05/11	26.2 ± 5.9	0.04 ± 0.02	0.11 ± 0.01	-	-	-	-	-
	87/05/21	16.6 ± 1.4	0.02 ± 0.00	0.12 ± 0.01	94.3 ± 2.0	13.2 ± -.3	106.2 ± 0.1	13.7 ± 0.0	21
	87/07/27	21.5 ± 6.1	0.03 ± 0.01	0.00 ± 0.00	90.7 ± 5.8	16.8 ± 0.7	106.1 _ 0.3	37.8 ± 0.00	10 & 21
	87/10/14	23.9 ± 8.0	0.03 ± 0.01	0.00 ± 0.00	72.3 ± 2.9	14.5 ± 0.6	106.8 ± 0.3	37.8 ± 0.0	21
52954	86/12/10	23.7 ± 6.6	0.03 ± 0.01	0.12 ± 0.02	-	13.8 ± 1.2	107.0 ± 0.1	13.2 ± 0.0	0
	86/12/16	26.0 ± 4.6	0.05 ± 0.02	0.11 ± 0.01	-	-	106.9 ± 0.2	13.3 ± 0.01	21
	87/01/26	25.6 ± 8.3	0.05 ± 0.01	0.14 ± 0.03	-	11.4 ± 0.8	106.5 ± 0.1	21.6 ± 12.1	0
	87/03/11	39.4 ± 12.1	0.21 ± 0.09	0.18 ± 0.07	61.7 ± 5.7	16.7 ± 2.4	107.8 ± 0.1	26.2 ± 10.1	24
	87/04/13	34.1 ± 9.7	0.09 ± 0.02	0.10 ± 0.01	75.9 ± 2.7	13.1 ± 0.8	106.3 ± 0.2	39.6 ± 8.6	24
	87/04/30	35.9 ± 13.3	0.15 ± 0.12	0.16 ± 0.10	79.2 ± 6.8	14.8 ± 0.6	106.0 ± 0.3	41.4 ± 8.8	23 & 24
	87/05/20	18.8 ± 3.6	0.02 ± 0.01	0.09 ± 0.02	85.3 ± 5.6	14.2 ± 1.8	106.2 ± 0.2	16.5 ± 0.0	,0,15,23,24
	87/06/02	34.3 ± 9.9	0.13 ± 0.07	0.24 ± 0.13	88.9 ± 6.3	17.7 ± 1.3	105.7 ± 0.3	31.9 ± 9.8	24 & 26
	87/07/27	24.7 ± 4.6	0.07 ± 0.01	-	95.8 ± 0.3	16.6 ± 0.1	103.9 ± 2.3	26.0 ± 13.6	21
47K	86/12/30	9.7 ± 6.8	0.01 ± 0.00	0.05 ± 0.02	55.0 ± 3.0	11.9 ± 0.2	107.0 ± 0.2	22.6 ± 1.8	23
	87/03/24	17.6 ± 10.0	0.04 ± 0.02	0.06 ± 0.03	51.7 ± 1.0	14.6 ± 0.1	105.8 ± 0.2	21.7 ± 0.0	23
	87/03/30	11.9 ± 8.2	0.03 ± 0.01	0.06 ± 0.02	49.3 ± 2.5	11.9 ± 0.3	105.0 ± 1.0	25.7 ± 2.4	23
	87/04/27	7.4 ± 8.5	0.03 ± 0.03	0.04 ± 0.03	58.3 ± 2.5	15.8 ± 0.2	105.3 ± 0.1	23.4 ± 1.6	23
	87/04/28	12.1 ± 8.7	0.03 ± 0.01	0.06 ± 0.02	46.9 ± 1.8	14.5 ± 0.1	106.0 ± 0.0	23.5 ± 1.3	23

1.) Horizontal bars indicate data not available.
2.) Mining Activity description is shown in Table 1.
3.) The values given represent daily average values.
4.) Large standard deviations usually indicate variations of Q and/or mining activity during measurement.

TABLE 12

Correlation of WL and RH for several locations

Location	WL(Rn) - f(RH)	A	B	C	R^2
47K	-	-	-	-	-
38952	$y = A+Bx+Cx^2$	2.27	-0.053	0.36×10^{-3}	0.34
52954	-	-	-	-	-
52984	$y = 1/A(x+B)^{1+C}$	0.075	-79.84	29.53	0.43
53951	$y = A + Bx$	-0.0418	0.128×10^{-2}	0	0.44
49683	-	-	-	-	-
26680	$y = A + (B/x)+(C/x^2)$	0.164	-15.85	382.4	0.73
38068	$y = A + (B/x)+(C/x^2)$	0.668	-79.65	2574	0.28
98100	$y = 1/(A+Bx)$	12.65	-0.113	0	0.42

Location	WL(Tn) - f(RH)	A	B	C	R^2
47K	-	-	-	-	-
38952	$y = A+(B/x)$	0.0936	24.36	0	0.48
52954	-	-	-	-	-
52984	-	-	-	-	-
53951	$y = A+(B/x)+(C/x^2)$	1.73	-259	0.1×10^3	0.68
49683	$y = A+Bx$	0.126	0.29×10^{-2}	0	0.60
26880	-	-	-	-	-
38068	$y = A(x/B)^{C \exp(x/B)}$	0.11×10^6	0	0	0.27
98100	-	-	-	-	-

Note: R^2 indicates correlation coefficient. Horizontal bars mostly indicate $R^2 < 0.2$.

TABLE 13

Correlation of WL and RH for several locations

Location	WL(Rn) - f(T)	A	B	C	R^2
47K	-	-	-	-	-
38952	$y = A(x/b)^{exp(x/b)}$	1.86	0	0	0.45
52954	-	-	-	-	-
52984	-	-	-	-	-
53951	-	-	-	-	-
49683	$y = A(x/B)^{exp(x/B)}$	0.02	-	-	0.44
26680	$y = A+Bx+Cx^2$	$0.99x10^{-2}$	$-0.23x10^{-2}$	$0.22x10^{-3}$	0.68
38068	$y = A+Bx+Cx^2$	-0.50	0.0987	$0.38x10^{-2}$	0.53
98100	-	-	-	-	-

Location	WL(Tm) - f(T)	A	B	C	R^2
47K	$y = AB^x$	0	0.017	53.67	0.23
38952	-	-	-	-	-
52954	-	-	-	-	-
52984	$y = 1/(A+Bx)$	$0.83x10^4$	$0.815x10^3$	-	0.24
53951	-	-	-	-	-
49683	$y = A(x/B)^{exp(x/B)}$	0.02	0	0	0.44
26680	-	-	-	-	-
38068	$y = A(x/B)^{exp(x/B)}$	$0.11x10^4$	0	0	0.27
98100	-	-	-	-	-

Note: R^2 indicates correlation coefficient. Horizontal bars mostly indicate $R^2 < 0.2$.

TABLE 14

Correlation of [^{222}Rn] and T for several locations

Location	[^{222}Rn] = f(T)	A	B	C	R^2
47E	$y = 1/A\ (x+B)^{2}+C$	0.031	-13.19	0.051	0.24
38952	-	-	-	-	-
52954	-	-	-	-	-
52984	-	-	-	-	-
53951	-	-	-	-	-
49683	-	-	-	-	-
26680	$y = A+Bx$	-3.36	0.787	0	0.31
38068	$y = A+Bx+Cx^2$	-408	75.77	-2.91	0.61
98100	-	-	-	-	-

Note: R^2 indicates correlation coefficient. Horizontal bars mostly indicate $R^2 < 0.2$

TABLE 15

Correlation of WL and Q for several locations

Location	WL(En) - f(Q)	A	B	C	R^2
47K	-	-	-	-	-
38952	$y = A+(B/x)+(C/x^2)$	3.02	-354.8	0.12×10^3	0.44
52954	$y = A \exp(x-B)/2)$	0.042	18.36	653.9	0.44
52984	-	-	-	-	-
53951	-	-	-	-	-
49683	$y = A+B/x$	-0.02	0.392	0	0.52
26680	$y = A + (B/x)+(C/x^2)$	0.046	- 0.65	2.63	0.45
38068	$y = A + Bx + (C/x)$	-0.07	0.43×10^{-2}	0.99	0.50
98100	$y = 1/(A+Bx)$	1.82	0.102	0	0.55

Location	WL(Tm) - f(Q)	A	B	C	R^2
47K	-	-	-	-	-
38952	$y = A+(B/x)^{C \exp(x/B)}$	7549	0	0	0.39
52954	$y = A+Bx+Cx^2$	0.234	-0.0112	0.23×10^{-3}	0.36
52984	-	-	-	-	-
53951	-	-	-	-	-
49683	$y = A+Bx+Cx^2$	0.119	0.79×10^{-2}	0.198×10^{-3}	0.33
26680	$y = B^{(1/x)}$	0.957	0.37×10^{-11}	0	0.33
38068	$y = A(x/B)^{C \exp(x/B)}$	0.037	0	0	0.44
98100	$y = A+Bx+(C/x)$	0.485	-0.997×10^{-2}	-0.399	0.21

Note: R^2 indicates correlation coefficient. Horizontal bars mostly indicate $R^2 < 0.2$.

TABLE 16

Correlation of [^{222}Rn] and Q for several locations

Location	[^{222}Rn] = f(Q)	A	B	C	R^2
47K	-	-	-	-	-
38952	?	-	-	-	-
52954	$y = A+Bx+Cx^2$	40.68	-1.55	0.033	0.46
52984	-	-	-	-	-
53951	-	-	-	-	-
49683	$y = A+(B/x)$	3.99	67.59	0	0.44
26680	$y = A+(B/x)$	-2.90	58.73	0	0.38
38068	$y = A+(B/x)+(C/x^2)$	63.88	-747.6	5024	0.61
98100	$y = A+Bx+(C/x)$	88.00	-1.67	-30.75	0.31

Note: R^2 indicates correlation coefficient. Horizontal bars mostly indicate $R^2 < 0.2$

TABLE 17

Radiation and Meteorological data (daily average values)

mostly for locations where mining activity changes took place

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL(Rn)	WL(Tn)	Mining Activity	Air Flow (m^3/s)	R H %	Temperature °C	Pressure (kPa)
26680	86/12/22	2.73 ± 2.0	0.001 ± .003	0.088 ± .03	21	9.44	59.45 ± 2.63	8.56 ± .43	102.7 ± .16
	87/03/09	4.87 ± 4.6	0.011 ± .01	0.040 ± .02	21	9.56 ± .21	N/A	8.61 ± 0.33	N/A
	87/04/29	2.41 ± 1.8	0.008 ± .004	0.046 ± .02	21	8.73 ± .75	58.61 ± 1.30	10.44 ± .18	100.4 ± .15
	87/06/01	10.08 ± 3.7	0.037 ± .01	0.039 ± .02	21	4.72	90.43 ± 4.36	17.42 ± 1.33	102.3 ± .05
	86/10/05	9.06 ± 5.3	0.015 ± .01	N/A	21	4.72	69.26 ± 1.89	13.32 ± 0.28	101.7 ± .25
38068	87/01/06	46.03 ± 8.23	0.088 ± 0.02	0.126 ± .02	16	15.57 ± 9.06	84 ± 3.51	9.47 ± 0.41	103.8 ± 0.17
	87/01/12	30.94 ± 4.6	0.050 ± 0.02	0.070 ± .02	23	14.75 ± 5.59	78.39 ± 4.58	8.99 ± .21	102.3 ± .17
	87/01/12	50.91 ± 3.1	0.085 ± .01	0.080 ± .01	12	7.08	90.63 ± 2.01	9.57 ± .48	102.2 ± .10
	87/01/14	43.28 ± 6.0	0.082 ± .004	0.090 ± .01	23	25.96	77.34 ± 12.02	10.26 ± 3.02	102.6 ± .10
	87/01/14	78.82 ± 18.5	0.122 ± .007	0.100 ± .02	12	6.14	89.13 ± 1.99	10.99 ± .64	102.6 ± .14
38070	87/01/08	24.76 ± 7.5	0.037 ± .005	0.071 ± .024	13	11.33	69.27 ± 2.23	8.03 ± .05	103.4 ± .12
	87/01/08	41.37 ± 7.2	0.087 ± .008	0.092 ± .02	16	11.33	77.67 ± 1.67	9.04 ± .204	103.4 ± .15
38954	87/04/02	18.42 ± 12.9	0.028 ± .02	0.062 ± .013	23	20.06 ± .15	76.29 ± 2.18	8.82 ± 0.44	102.3 ± .15
	87/03/10	10.60 ± 2.3	0.023 ± .006	0.053 ± .04	23	18.88	60.96 ± 1.25	7.72 ± .15	105.7 ± .12
	87/03/10	22.23	0.020	0.110	11	18.88	100	6.00	105.4
38952	86/12/18	90.78 ± 15.2	0.432 ± .03	0.525 ± .09	21	76.93	60.38 ± 8.91	13.72 ± .19	104.2 ± .18
	87/03/05	85.61 ± 9.9	0.369 ± .03	0.370 ± .02	21	70.05 ± 3.9	83.51 ± .36	12.47 ± .45	105.9 ± .23
	87/05/05	83.75 ± 6.2	0.443 ± .02	0.371 ± .04	21	80.13 ± .13	87.80 ± 1.61	12.83 ± .16	105.7 ± .13
38071	87/04/02	25.12 ± 1.7	0.030	0.078 ± .02	13	7.08	85.32 ± 2.83	9.50 ± 0.29	102.2 ± .18
	87/04/06	38.42 ± 16.2	0.037 ± 0.01	0.040 _ .02	13	7.08	90.91 ± 5.05	9.47 ± .33	103.6 ± .24
	87/04/06	10.49 ± 2.9	0.035 ± .01	0.025 ± .02	23	7.08	80.44 ± 1.0	8.36 ± .04	103.9 ± .141
38062	87/05/26	61.6 ± 2.4	0.300 ± .01	0.010 ± .01	23	4.25	90.8 ± .02	12.61 ± .08	104.3 ± .14
	87/05/26	74.74 ± 37.6	0.335 ± .09	0.205 ± .18	11	4.25	93.4 ± 2.14	13.15 ± .22	104.2 ± .05

Cont.

Table 17 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL(Rn)	WL(Tn)	Mining Activity	Air Flow (m^3/s)	R H %	Temperature °C	Pressure (kPa)
43951	87/06/11	148.76 ± 3.6	0.76 ± .05	0.41	31	N/A	86.1 ± 3.8	15.56	105.6 ± .14
49663	87/01/29	9.28 ± 2.2	0.018 ± .007	0.050 ± 0.13	12	8.97	70.34 ± 9.87	11.77 ± .31	106.6 ± .12
	87/01/29	5.25 ± .35	0.01	0.030 ± .02	23	8.97	50.89 ± 1.23	7.65 ± .25	106.4 ± .10
	87/03/23	9.99 ± 4.43	0.023 ± .006	0.053 ± .01	17	15.58 ± 8.17	67.84 ± 2.31	11.85 ± .50	106.0 ± .21
	87/03/23	11.12 ± 4.81	0.030	0.020	23	8.50	62.62 ± .96	11.78 ± .23	106.3 ± .28
	87/04/14	39.44 ± .91	0.220 ± .02	0.135 ± .01	0	3.78	72.5	12.72	106.
	87/04/14	14.24 ± .99	0.025 ± .01	0.065 ± .01	23	18.41	63.47 ± .05	13.20 ± .04	106.5
49683	87/01/28	8.69 ± 3.4		0.065 ± .04	21	30.20	61.17 ± 4.83	7.89 ± .08	105.4 ± .07
	87/01/28	9.72 ± 7.4	0.005 ± .006	0.058 ± .02	14	12.27	59.61 ± .85	11.79 ± .63	105.7 ± .08
	87/03/23	5.69 ± .41	0.005 ± .007	0.040 ± .03	21	16.28 ± 5.7	63.53 ± 3.27	11.05 ± .39	106.1 ± .07
	87/03/23	6.88 ± 1.17	0.01	0.06	17	10.85	68.07 ± .05	11.20 ± .03	106.5 ± .07
	87/04/14	17.5 ± 9.67	0.057 ± .06	0.07 ± 0.04	21	8.65 ± 7.19	65.87 ± 11.9	12.98 ± .78	106.6 ± .17
40143	87/04/28	2130.27	10.34	0.15	0	23.13	N/A	N/A	104.15 ± .07
40144	87/05/07	0.97	0.07	N/A	21	10.38	68.82	10.56	104.7
	87/05/07	155.5 ± 115.8	0.69 ± .79	N/A	0	15.86 ± 4.14	76.98 ± 11.2	11.88 ± .21	104.8 ± .13
52113	86/12/08	28.64 ± 10.3	0.039 ± .02	0.199 ± .03	26	13.21	96.55 ± 79.1	12.75 ± 2.16	108.0 ± .19
	87/01/19	30.54 ± 6.5	0.063 ± .01	0.148 ± .034	0	12.74	65.03 ± 1.31	13.41 ± 1.58	105.8 ± .09
	87/04/13	53.27 ± 0.48	0.210 ± 0.26	0.170 ± .02	25	8.97	85.62 ± 2.28	14.50 ± .24	106.2 ± .10
50106	87/01/20	41.33 ± 5.68	0.141 ± .022	0.177 ± .05	0	22.18 ± 18.76	63.16 ± 7.97	18.31 ± 3.7	105.7 ± .23
	87/01/21	43.62	0.12	0.24	12	11.94	77.16	15.72	105.1
	87/05/06	44.03 ± 4.8	0.167 ± .006	0.22 ± .04	24	77.39	86.23 ± .66	14.15 ± .03	105.97 ± .12
	87/05/06	55.65 ± 15.4	0.203 ± .02	0.22 ± .02	0	10.01	88.48 ± 1.04	14.82 ± .23	105.6 ± .06

Cont.

Table 17 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL(Rn)	WL(Tn)	Mining Activity	Air Flow (m^3/s)	R H %	Temperature °C	Pressure (kPa)
Cr. Dec.	87/01/15	11.15 ± 3.32	0.031 ± .01	0.077 ± .01	24	55.13 ± 2.08	88.64 ± 1.12	9.86 ± .27	106.2 ± .21
	87/01/15	9.39 ± 1.15	0.033 ± .05	0.097 ± m.01	23	53.8	87.79 ± .67	9.74 ± .12	106.5 ± .06
NWR U/G	87/06/04	1.99 ± 1.5	0	0.01 ± .01	21	N/A	N/A	N/A	103.1 ± .21
	87/06/04	4.88	0.01	0.03	42	N/A	N/A	N/A	103.2
98100	86/12/29	48.27 ± 3.27	0.269 ± .019	0.312 ± 0.110	21	19.9 ± 1.33	77.55 ± 2.04	12.50	103.3 ± .16
	87/01/05	77.62 ± 32.01	0.694 ± .420	0.445 ± .149	21	6.14	83.77 ± 7.98	12.79 ± .36	104.1 ± .11
	87/03/25	47.77 ± 6.49	0.227 ± .017	0.207 ± .033	23	24.41 ± 1.92	77.68 ± 1.06	12.03 ± .11	101.3 ± .25
	87/03/26	70.00 ± 11.30	0.474 ± .141	0.272 ± .03	23	4.96	89.77 ± 4.5	12.01 ± .39	100.8 ± .17
	87/04/21	58.39 ± 7.14	0.275 ± .018	0.249 ± .031	23	17.69	90.97 ± 1.33	12.93 ± .13	102.9 ± .18
	87/04/22	68.60 ± 12.82	0.508 ± .148	0.261 ± .036	23	1.89	87.17 ± 5.69	12.11 ± .39	103.5 ± .14
52984	86/12/04	12.21 ± 2.94	0.006 ± .007	0.091 ± .039	21	39.01	N/A	14.16 ± 1.36	105.9 ± .38
	86/12/09	23.3 ± 6.05	0.041 ± .009	0.132 ± .027	23	35.92 ± 1.46	64.32 ± 2.81	12.25 ± .46	106.3 ± .19
	86/12/15	25.1 ± 5.57	0.032 ± .02	0.120 ± .03	0	19.8 ± 10.2	N/A	17.0 ± 2.42	107.1 ± .15
	86/12/16	23.94 ± 1.46	0.040 ± .028	0.150 ± 0.14	21	26.19 ± 18.35	N/A	N/A	107.0 ± .07
	87/03/04	15.75 ± 8.13	0.012 ± .004	0.048 ± .025	21	35.51 ± 2.5	54.22 ± 4.06	8.56 ± .14	107.7 ± .30
	87/04/20	15.26 ± 3.49	0.022 ± .006	0.087 ± .053	21	37.17 ± 2.5	94.12 ± 2.32	12.6 ± .50	106.9 ± .45
	87/05/21	16.87 ± 1.71	0.02	0.12 ± .015	21	13.71	96.9 ± 1.1	12.74 ± .14	106.2 ± .06
	87/05/21	16.8 ± 1.07	0.02 ± .004	0.125 ± .02	0	13.71	93.06 ± .48	13.39 ± .07	106.3 ± .13
	87/07/27	18.4	0.01	N/A	10	37.76	83.82	17.72	106.6
	87/07/27	22.15 ± 6.55	0.032 ± .01	N/A	21	37.76	92.03 ± 5.23	16.57 ± .65	106.0 ± .19
	87/10/14	23.86 ± 8.01	0.031 ± .01	N/A	21	37.76	72.33 ± 2.86	14.49 ± .56	106.8 ± .31
45983	86/12/23	199.02 ± 30.8	1.638 ± .174	0.694 ± .115	24	4.72	66.26 ± 6.8	15.6 ± .32	106.1 ± .04
	87/03/12	181.32 ± 25.06	1.860 ± .318	0.343 ± .201	23	4.11	51.32 ± 5.5	14.99 ± .13	106.6 ± .13
	87/05/14	120.27 ± 32.04	0.862 ± .291	0.346 ± .150	23	4.11	69.42 ± 8.8	14.38 ± .95	105.4 ± .17

Cont.

Table 17 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL(Rn)	WL(Tn)	Mining Activity	Air Flow (m^3/s)	R H %	Temperature °C	Pressure (kPa)
52954	86/12/10	23.68 ± 6.6	0.03 ± .007	0.116 ± .024	0	13.21	N/A	13.80 ± 1.18	107.0 ± .1
	86/12/16	33.04	0.05	0.16	21	13.21	N/A	N/A	106.9
	86/12/16	25.2 ± 4.08	0.046 ± .019	0.107 ± .04	0	13.27 ± .14	63.32 ± .5	11.45 ± .08	106.9 ± .24
	87/01/26	25.66 ± 8.3	0.049 ± .014	0.142 ± .03	0	21.60 ± 12.1	60.73 ± 2.51	11.44 ± .80	106.5 ± .14
	87/03/11	39.42 ± 12.1	0.21 ± .094	0.178 ± .071	24	26.19 ± 10.1	61.68 ± 5.71	16.69 ± 2.39	107.8 ± .10
	87/04/13	34.13 ± 9.69	0.087 ± 0.22	0.103 ± .011	24	39.64 ± 8.6	75.95 ± 2.73	13.12 ± .81	106.3 ± .21
	87/04/30	23.85 ± 2.78	0.043 ± .008	0.068 ± .015	24	41.41 ± 8.78	79.2 ± 6.81	14.77 ± .60	106 ± .26
	87/05/20	20.44 ± 3.27	0.02 ± .01	0.09 ± .06	23	16.52	88.55 ± 0.74	13.2 ± .42	106.2 ± .12
	87/05/20	14.63 ± .80	0.02	0.115 ± .049	24	16.52	87.80 ± .02	12.75 ± .04	015.9 ± .071
	87/05/20	16.97 ± 2.04	0.03	0.07 ± 0.01	15	16.52	75.59 ± 2.38	17.28 ± .63	106.4 ± .071
	87/05/20	22.32 ± .82	0.03	0.01 ± .014	0	16.52	87.67 ± .21	13.98 ± .59	106.3 ± .21
	87/06/02	36.99 ± 10.0	0.15 ± .066	0.28 ± .126	24	37.05 ± 10.1	91.25 ± 5.35	17.22 ± .95	105.8 ± .263
	87/06/02	26.19 ± 2.86	0.05	0.103 ± .015	26	27.84	81.83 ± 2.53	19.21 ± .89	105.5 ± .06
	87/07/27	24.66 ± 4.61	0.068 ± .015	N/A	21	25.96 ± 13.6	95.77 ± .26	16.63 ± .03	103.9 ± 2.28
99400	86/12/12	0.92 ± .77	0.007 ± 0.01	0.027 ± 0.01	23	15.28 ± 1.9	69.56	5.00	97.6 ± .40
	86/12/12	2.73 ± 3.75		0.02 ± 0.014	24	15.84 ± 2.4	76.46	4.44	97.4 ± .28
	87/05/25	2.78 ± 0.92	0.004 ± 0.01	0.01 ± .01	23	61.35	81.74 ± 7.35	9.46 ± 1.31	98.5 ± .34
53951	87/06/08	27.51 ± 1.7	0.078 ± .004	0.125 ± .005	24	N/A	93.11 ± 1.70	17.8 ± 0.39	107.2 ± .12
	87/06/10	17.07 ± 2.8	0.05 ± .01	0.087 ± .012	24	40.89 ± 15.4	77.77 ± 4.13	18.1 ± .85	108.9 ± .19
	87/06/10	21.11 ± .148	0.07 ± .01	0.115 ± .007	23	47.19	85.94 ± 1.41	16.9 ± .20	109.1 ± .07
	87/06/17	27.66 ± .69	0.075 ± .007	0.10	26	47.19 ±	79.12 ± 5.61	20.42 ± 1.14	108.5
	87/06/17	23.92	0.07	0.07	24	47.19	81.68	19.72	108.5
53004	87/06/17	22.28 ± 2.2	0.08	0.097 ± .03	24	47.19	82.66 ± 3.4	19.33 ± .67	108.9 ± .06
	87/06/17	31.39 ± 3.5	0.09	0.097 ± .01	16	4.01	90.89 ± .29	18.24 ± .03	108.9
50966	87/01/22	34.04 ± 3.8	0.105 ± .015	0.200 ± .05	0	38.35 ± 16.4	70.72 ± 4.45	15.1 ± 0.67	104.9 ± .57
	87/03/11	37.37 ± 2.7	0.230	0.180 ± .03	23	45.78	71.67 ± .12	14.42 ± .12	107.5 ± .14
	87/05/13	40.13 ± 13.4	0.14 ± .005	0.17 ± 0.04	23	80.70	86.63 ± .02	14.39	107.4 ± .35
	87/05/13	30.12 ± 23.5	0.15 ± .011	0.18 ± .021	21	91.09	87.49 ± 2.9	14.07 ± .12	107.1 ± .15
	87/05/13	38.20	0.14	0.16	13	83.06	86.59	14.22	106.9
	87/05/13	51.12	0.16	0.15	11	83.06	87.65	14.00	106.9

Cont.

Table 17 - cont.

Location	Date YY/MM/DD	[^{222}Rn] (pCi/L)	WL(Rn)	WL(Tn)	Mining Activity	Air Flow (m^3/s)	R H %	Temperature °C	Pressure (kPa)
59882	87/04/07	10.51 ± 2.7	0.01 ± .007	0.054 ± .017	17	30.42 ± 2.5	53.6 ± 4.76	14.42 ± .48	108.9 ± .25
	87/04/07	5.53	0.01	0.05	24	33.20	47.97	14.94	108.5
59852	87/04/07	12.09 ± 1.67	0.02	0.04 ± .01	24	29.63 ± 1.84	65.78 ± 2.31	14.85 ± .661	108.7 ± .06
	87/04/07	17.72 ± 11.3	0.023 ± 0.01	0.073 ± .015	26	36.18	69.25 ± 8.17	17.17 ± 1.969	108.4 ± .058
53007	87/06/09	16.6 ± .73	0.06	0.095 ± .02	23	N/A	84.05 ± 1.01	16.91 ± .28	108.9
	87/06/09	17.2	0.06	0.07	24	N/A	83.97	17.17	108.6
	87/06/09	18.09 ± 2.1	0.043 ± .01	0.07	13	N/A	92.69 ± 6.27	15.85 ± 1.52	108.6 ± .15
57852	86/12/17	7.52 ± 2.1	0.015 ± .01	0.08 ± .03	23	37.76	64.28 ± .03	12.78	109.0 ± .19
	86/12/17	13.73 ± 8.9	0.02	0.065 ± .04	24	37.76	64.11 ± 1.03	13.19 ± .28	108.8 ± .17
47E	86/12/30	9.73 ± 6.79	0.006 ± .005	0.048 ± .019	23	25.56 ± 1.81	54.97 ± 3.03	11.89 ± .23	
	87/03/24	17.59 ± 9.99	0.043 ± .019	0.056 ± .032	23	21.71	51.72 ± 1.00	14.56 ± .13	
	87/03/30	11.95 ± 8.21	0.035 ± .014	0.065 ± .023	23	25.66 ± 2.4	49.3 ± 2.53	11.88 ± .31	
	87/04/27	7.45 ± 8.47	0.031 ± .028	0.038 ± .026	23	23.41 ± 1.56	58.3 ± 2.47	15.81 ± .20	
	87/04/28	12.11 ± 8.69	0.033 ± .014	0.061 ± .021	23	23.5 ± 1.31	46.95 ± 1.80	14.54 ± .07	

TABLE 18

Effect of mining operations or activities on airborne radioactivity

for several underground locations

Location	Description	Operations	Δ[^{222}Rn] %	ΔWL(Rn) %	ΔWL(Tn) %
38070	Jackleg stope	Drilling (13) Slushing (16)	67	149	31
38954	Travelway	No traffic (23) Setting up (11)	53	0	90
38071	Jackleg stope	No traffic (23) Drilling (13)	200	0	136
38062	Jackleg stope	No traffic (23) Setting up (11)	21	12	?
45983	Exhaust airway	No traffic (23) Traffic (24)	32	21	104
Cr Dec	Crusher decline	No traffic (23) Traffic (24)	19	0	-21
57852	Travelway	No traffic (23) Traffic (24)	83	33	-19

Notes: 1.) The symbol Δ is used to indicate increment.
2.) The number in round brackets indicates the mining operations or activity (see Table 1) which is shown on the left hand side of the number.

Table A-1 - Radon flux calculated according to Eq. 15.
Also shown are other data of interest.

$$J = \frac{\{Rn(2) - Rn(1) \times e^{(-L \times t)}\} \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
04-May-87	101.00	102.00	188.77	21798.78	36552.83	193.64	6.68	3.00	1.18	76.41	2.83
11-Dec-86	103.00	104.00	206.30	14872.10	28338.61	137.37	8.46	0.89	3.89	178.49	6.60
04-Jun-87	103.00	104.00	212.36	14872.10	28338.61	133.45	2.72	2.66	0.03	39.35	1.46
12-Dec-86	202.00	201.00	15.84	6383.38	8133.18	513.46	0.93	2.12	-0.11	0.59	0.02
01-Apr-87	202.00	201.00	18.88	6383.38	8133.18	430.78	4.24	2.98	0.14	14.72	0.54
25-May-87	202.00	201.00	24.07	6383.38	8133.18	337.90	2.63	2.43	0.03	10.36	0.38
29-Dec-86	203.00	204.00	19.89	1353.36	1333.05	67.02	47.91	48.62	-0.39	698.15	25.83
25-Mar-87	203.00	204.00	24.24	1353.36	1333.05	54.99	46.23	49.30	-2.03	796.12	29.46
21-Apr-87	203.00	204.00	17.69	1353.36	1333.05	75.36	53.75	63.02	-4.48	632.17	23.39
05-Jan-87	205.00	206.00	6.13	5549.63	6481.97	1057.42	106.81	48.44	2.39	155.72	5.76
26-Mar-87	205.00	206.00	4.96	5549.63	6481.97	1306.85	74.47	65.54	0.30	71.38	2.64
22-Apr-87	205.00	206.00	1.89	5549.63	6481.97	3429.61	77.38	59.81	0.22	30.01	1.11
15-Jan-87	208.00	207.00	54.73	1165.97	1104.53	20.18	8.92	12.33	-5.92	325.57	12.05
09-Apr-87	208.00	207.00	67.40	1165.97	1104.53	16.39	16.23	15.14	2.33	974.89	36.07
27-May-87	208.00	207.00	63.87	1165.97	1104.53	17.29	45.24	40.09	10.44	2642.44	97.77
30-Dec-86	209.00	210.00	22.79	830.61	788.95	34.62	11.12	6.62	4.57	376.98	13.95
24-Mar-87	209.00	210.00	21.71	574.81	321.02	14.79	24.45	8.44	22.37	1275.39	47.19
30-Mar-87	209.00	209.10	25.77	490.04	467.93	18.16	7.61	9.21	-3.11	351.24	13.00
27-Apr-87	209.00	209.10	23.41	490.04	467.93	19.99	5.55	3.37	3.85	325.75	12.05
28-Apr-87	209.00	209.10	23.50	490.04	467.93	19.91	6.45	8.02	-2.79	265.51	9.82
30-Mar-87	209.10	210.00	25.77	340.57	321.02	12.46	17.13	7.61	26.65	1715.43	63.47
27-Apr-87	209.10	210.00	23.41	340.57	321.02	13.71	5.71	5.55	0.41	398.90	14.76
28-Apr-87	209.10	210.00	23.50	340.57	321.02	13.66	19.10	6.45	32.30	1825.95	67.56
28-Apr-87	210.00	211.00	23.50	560.59	673.33	28.65	12.15	19.10	-10.78	339.81	12.57
22-Dec-86	301.00	302.00	9.44	2135.45	2181.22	231.06	4.34	1.11	0.53	27.50	1.02
09-Mar-87	301.00	302.00	9.56	2135.45	2181.22	228.16	5.41	5.21	0.03	24.75	0.92
29-Apr-87	301.00	302.00	8.73	2135.45	2181.22	249.85	3.68	1.15	0.38	21.07	0.78
01-Jun-87	301.00	302.00	4.72	2135.45	2181.22	462.12	10.76	9.24	0.12	25.76	0.95
23-Mar-87	303.00	305.30	13.57	1632.58	1575.85	116.13	6.88	5.69	0.37	62.96	2.33
23-Mar-87	303.00	308.00	19.23	7850.98	8617.20	448.11	19.85	5.69	1.28	68.84	2.55
14-Apr-87	303.00	308.00	18.16	3451.81	1575.85	86.78	14.24	9.85	0.85	88.37	3.27
23-Mar-87	305.30	306.10	16.75	3365.18	3699.21	220.85	10.56	6.88	0.68	63.24	2.34

Cont.

Table A-1 - cont.

$$J = \frac{\{Rn(2) - Rn(1) \times e^{(-L \times t)}\} \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
29-Jan-87	307.00	306.10	8.97	3365.18	3699.21	412.40	9.95	5.26	0.46	33.82	1.25
12-Mar-87	402.00	401.00	4.11	1287.71	1952.83	475.14	217.70	189.58	3.32	747.73	27.67
14-May-87	402.00	401.00	4.11	1287.71	1952.83	475.14	148.75	154.51	-0.68	464.55	17.19
12-Mar-87	403.00	402.00	4.11	1165.55	1788.44	435.14	217.70	151.80	8.60	903.53	33.43
14-May-87	403.00	402.00	4.11	1165.55	1788.44	435.14	148.75	88.08	7.92	649.44	24.03
23-Dec-86	404.00	401.00	4.72	3615.51	5861.16	1241.77	221.55	176.48	2.18	324.18	11.99
14-May-87	404.00	401.00	4.11	3615.51	5861.16	1426.07	154.51	101.16	2.24	211.40	7.82
12-Mar-87	404.00	403.00	4.11	938.49	1463.95	356.19	151.80	175.90	-3.91	603.89	22.34
14-May-87	404.00	403.00	4.11	938.49	1463.95	356.19	88.08	101.16	-2.12	352.70	13.05
18-Mar-87	405.00	405.10	0.46	390.58	395.83	860.51	399.00	56.73	14.91	705.12	26.09
18-Mar-87	406.00	406.10	0.46	571.46	559.06	1215.36	308.04	180.27	3.81	308.36	11.41
08-Apr-87	408.00	409.00	17.59	500.45	495.13	28.15	46.19	34.27	15.50	1867.43	69.10
08-Apr-87	408.00	410.00	17.59	1158.54	1164.38	66.20	40.62	34.27	3.57	672.92	24.90
12-May-87	408.00	410.00	15.80	1158.54	1164.38	73.69	38.60	31.15	3.76	585.63	21.67
12-May-87	408.00	409.00	15.80	500.45	495.13	31.34	34.67	31.15	4.11	1159.34	42.90
12-May-87	409.00	410.00	15.80	658.09	669.24	42.36	38.60	34.67	3.49	981.73	36.32
10-Jun-87	412.00	413.00	47.19	1761.14	1819.34	38.55	17.51	16.38	1.12	486.84	18.01
10-Jun-87	412.00	416.00	47.19	2995.52	3037.90	64.38	21.11	16.38	2.76	375.96	13.91
10-Jun-87	413.00	416.00	47.19	1234.38	1218.56	25.82	21.11	17.51	5.09	887.16	32.83
08-Jun-87	415.00	416.00	50.97	731.68	642.15	12.60	27.84	27.18	1.70	1966.18	72.75
10-Jun-87	415.00	416.00	47.19	731.68	642.15	13.61	21.11	16.74	10.43	1525.55	56.45
09-Jun-87	417.00	417.10	4.78	450.62	403.54	84.42	17.45	16.79	0.26	189.21	7.00
17-Mar-87	501.00	502.00	61.35	5792.87	6266.52	102.14	11.15	4.44	2.63	159.46	5.90
17-Dec-86	504.00	507.00	37.75	6048.76	6793.83	179.97	13.74	7.52	1.44	108.37	4.01
17-Mar-87	504.00	505.00	61.35	2232.73	2494.49	40.66	14.92	11.43	3.55	465.81	17.23
17-Mar-87	504.00	506.00	61.35	4499.89	5252.96	85.62	12.30	7.52	2.41	205.65	7.61

Cont.

Table A-1 - cont.

$$J = \frac{\{ Rn(2) - Rn(1) \times e^{(-L \times t)}\} \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
17-Mar-87	505.00	506.00	61.35	2258.73	2738.22	44.63	12.30	14.92	-2.63	292.70	10.83
07-Apr-87	508.00	509.00	31.89	5894.23	6737.15	211.26	9.82	9.53	0.06	54.07	2.00
07-Apr-87	510.00	511.00	31.89	5323.17	6105.46	191.45	17.72	12.10	1.25	125.79	4.65
04-Dec-86	601.00	602.00	39.01	3962.11	4847.02	124.25	10.70	10.09	0.22	108.87	4.03
04-Mar-87	601.00	602.10	35.51	5186.74	8597.54	242.12	11.28	11.66	-0.10	75.75	2.80
20-Apr-87	601.00	602.10	37.16	5186.74	8597.54	231.37	12.90	11.97	0.25	96.34	3.56
04-Mar-87	601.00	602.20	35.51	5786.36	9348.36	263.26	14.95	11.66	0.75	103.54	3.83
20-Apr-87	601.00	602.20	37.16	5786.36	9348.36	251.57	16.23	11.97	1.01	120.20	4.45
04-Dec-86	601.00	603.00	39.01	7728.98	10207.93	261.67	14.70	10.09	0.86	87.77	3.25
04-Mar-87	601.00	603.00	35.51	7728.98	10207.93	287.47	25.10	11.66	2.28	151.31	5.60
20-Apr-87	601.00	603.00	37.16	7728.98	10207.93	274.70	19.93	11.97	1.42	118.14	4.37
04-Dec-86	602.00	603.00	39.01	3749.44	5307.99	136.07	14.70	10.70	1.54	177.20	6.56
04-Mar-87	602.10	602.20	35.51	620.54	824.43	23.22	14.95	11.28	7.77	977.77	36.18
20-Apr-87	602.10	602.20	37.16	620.54	824.43	22.19	16.23	12.90	7.38	1088.00	40.26
04-Mar-87	602.10	603.00	35.51	1136.23	1519.52	42.79	25.10	11.28	15.98	1035.86	38.33
20-Apr-87	602.10	603.00	37.16	1136.23	1519.52	40.89	19.93	12.90	8.51	785.66	29.07
04-Mar-87	602.20	603.00	35.51	515.69	695.09	19.57	25.10	14.95	25.86	2135.18	79.00
20-Apr-87	602.20	603.00	37.16	515.69	695.09	18.71	19.93	16.23	9.86	1591.35	58.88
16-Dec-86	603.00	604.00	13.21	2064.62	3156.47	238.95	18.72	22.90	-0.99	104.28	3.86
15-Dec-86	603.00	605.10	13.63	1825.88	2580.35	189.31	27.39	25.42	0.54	213.10	7.88
10-Dec-86	604.00	606.10	16.52	2005.02	3520.05	213.08	22.62	18.72	1.19	205.15	7.59
16-Dec-86	604.00	606.10	13.21	2005.02	3520.05	266.47	27.02	26.60	0.10	179.73	6.65
26-Jan-87	604.00	606.10	13.52	2005.02	3520.05	260.36	30.89	19.17	2.92	254.39	9.41
30-Apr-87	607.00	608.00	33.51	1585.27	2057.12	61.39	24.00	23.69	0.24	511.20	18.91
13-Apr-87	607.00	609.10	33.51	2579.33	3039.61	90.71	53.27	24.66	13.75	908.49	33.61
09-Dec-86	607.00	610.00	35.92	1130.86	1497.95	41.70	22.01	20.07	2.28	735.03	27.20
13-Apr-87	607.00	610.00	34.92	1130.86	1497.95	42.90	36.57	24.66	13.61	1343.37	49.70
09-Dec-86	607.00	611.00	35.92	6687.24	9846.51	274.12	27.81	20.07	1.54	173.65	6.43

Cont.

Table A-1 - cont.

$$J = \frac{(Rn(2) - Rn(1) \times e^{(-L \times t)}) \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
30-Apr-87	607.00	611.00	33.51	6824.74	8626.98	257.44	43.02	23.69	3.51	266.56	9.86
08-Dec-86	608.00	609.10	13.21	1010.19	1080.45	81.79	25.11	20.88	2.05	360.60	13.34
19-Jan-87	608.00	609.10	12.74	1010.19	1080.45	84.81	26.63	28.32	-0.79	323.50	11.97
30-Apr-87	608.00	611.00	33.51	5219.89	6461.69	192.83	43.02	24.00	4.52	347.33	12.85
02-Jun-87	608.00	611.00	46.25	5219.89	6461.69	139.71	45.78	25.84	6.54	508.55	18.82
09-Dec-86	610.00	611.00	35.92	3694.73	5158.73	143.62	27.81	22.01	2.09	303.26	11.22
20-Jan-87	613.00	615.10	9.67	4022.35	5117.80	529.25	46.28	36.27	0.89	125.38	4.64
21-Jan-87	613.00	614.10	11.80	4078.12	5204.94	441.10	46.06	40.48	0.60	142.79	5.28
11-Mar-87	613.00	616.00	46.48	5180.14	6291.81	135.37	37.37	36.26	0.37	341.20	12.62
11-Mar-87	613.10	613.00	47.19	1462.30	1676.51	35.53	36.38	36.14	0.29	1178.62	43.61
06-May-87	614.00	615.10	10.01	4078.12	5204.94	519.97	47.70	44.04	0.33	122.44	4.53
21-May-87	617.00	617.10	13.71	504.91	511.46	37.31	16.57	16.50	0.07	451.07	16.69
20-May-87	618.00	618.10	16.52	583.73	693.50	41.98	18.56	16.27	2.40	563.02	20.83
13-May-87	620.00	614.10	84.79	4803.69	5685.86	67.06	22.64	50.87	-18.44	109.71	4.06
02-Jun-87	621.00	608.00	27.84	3514.37	4925.73	176.93	25.84	26.19	-0.10	203.16	7.52
02-Apr-87	701.00	702.10	7.39	949.58	659.04	89.18	25.73	8.36	5.00	278.94	10.32
06-Apr-87	701.00	702.10	7.08	949.58	659.04	93.09	27.72	10.21	4.83	282.69	10.46
10-Mar-87	701.00	703.00	18.88	849.57	814.73	43.15	22.23	10.63	9.54	644.08	23.83
08-Jan-87	703.00	704.10	11.33	1708.43	1809.14	159.68	41.37	24.76	4.08	338.54	12.53
06-Jan-87	705.00	706.10	9.44	824.10	809.80	85.78	48.29	44.05	1.80	581.52	21.52
12-Jan-87	705.00	706.10	9.20	824.10	809.80	88.02	49.80	29.88	8.23	685.46	25.36
14-Jan-87	705.00	706.10	6.13	824.10	809.80	132.11	66.60	39.84	7.36	611.36	22.62
14-Jan-87	705.00	707.00	25.96	442.82	488.78	18.83	43.58	39.84	8.11	2682.56	99.25
18-Dec-86	801.00	802.00	76.92	3275.67	3948.11	51.33	98.26	83.31	12.99	2511.90	92.94
05-Mar-87	801.00	802.00	70.50	3275.67	3948.11	56.00	91.39	79.03	9.84	2121.96	78.51
05-May-87	801.00	802.00	80.13	3275.67	3948.11	49.27	84.46	83.03	1.29	2086.64	77.21

Table A-2 - Radon flux calculated according to Eq. 16.
Also shown are other data of interest.

$$J = \frac{\{ Rn(2) - Rn(1) \} \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
04-May-87	101.00	102.00	188.77	21798.78	36552.83	193.64	6.68	3.00	1.18	50.42	1.87
11-Dec-86	103.00	104.00	206.30	14872.10	28338.61	137.37	8.46	0.89	3.89	166.14	6.15
04-Jun-87	103.00	104.00	212.36	14872.10	28338.61	133.45	2.72	2.66	0.03	1.36	0.05
12-Dec-86	202.00	201.00	15.84	6383.38	8133.18	513.46	0.93	2.12	-0.11	-4.67	-0.17
01-Apr-87	202.00	201.00	18.88	6383.38	8133.18	430.78	4.24	2.98	0.14	5.90	0.22
25-May-87	202.00	201.00	24.07	6383.38	8133.18	337.90	2.63	2.43	0.03	1.19	0.04
29-Dec-86	203.00	204.00	19.89	1353.36	1333.05	67.02	47.91	48.62	-0.39	-16.51	-0.61
25-Mar-87	203.00	204.00	24.24	1353.36	1333.05	54.99	46.23	49.30	-2.03	-86.99	-3.22
21-Apr-87	203.00	204.00	17.69	1353.36	1333.05	75.36	53.75	63.02	-4.48	-191.70	-7.09
05-Jan-87	205.00	206.00	6.13	5549.63	6481.97	1057.42	106.81	48.44	2.39	102.09	3.78
26-Mar-87	205.00	206.00	4.96	5549.63	6481.97	1306.85	74.47	65.54	0.30	12.64	0.47
22-Apr-87	205.00	206.00	1.89	5549.63	6481.97	3429.61	77.38	59.81	0.22	9.49	0.35
15-Jan-87	208.00	207.00	54.73	1165.97	1104.53	20.18	8.92	12.33	-5.92	-253.22	-9.37
09-Apr-87	208.00	207.00	67.40	1165.97	1104.53	16.39	16.23	15.14	2.33	99.68	3.69
27-May-87	208.00	207.00	63.87	1165.97	1104.53	17.29	45.24	40.09	10.44	446.30	16.51
30-Dec-86	209.00	210.00	22.79	830.61	788.95	34.62	11.12	6.62	4.57	195.33	7.23
24-Mar-87	209.00	210.00	21.71	574.81	321.02	14.79	24.45	8.44	22.37	956.61	35.39
30-Mar-87	209.00	209.10	25.77	490.04	467.93	18.16	7.61	9.21	-3.11	-133.11	-4.93
27-Apr-87	209.00	209.10	23.41	490.04	467.93	19.99	5.55	3.37	3.85	164.75	6.10
28-Apr-87	209.00	209.10	23.50	490.04	467.93	19.91	6.45	8.02	-2.79	-119.11	-4.41
30-Mar-87	209.10	210.00	25.77	340.57	321.02	12.46	17.13	7.61	26.65	1139.59	42.16
27-Apr-87	209.10	210.00	23.41	340.57	321.02	13.71	5.71	5.55	0.41	17.40	0.64
28-Apr-87	209.10	210.00	23.50	340.57	321.02	13.66	19.10	6.45	32.30	1380.88	51.09
28-Apr-87	210.00	211.00	23.50	560.59	673.33	28.65	12.15	19.10	-10.78	-460.92	-17.05
22-Dec-86	301.00	302.00	9.44	2135.45	2181.22	231.06	4.34	1.11	0.53	22.59	0.84
09-Mar-87	301.00	302.00	9.56	2135.45	2181.22	228.16	5.41	5.21	0.03	1.42	0.05
29-Apr-87	301.00	302.00	8.73	2135.45	2181.22	249.85	3.68	1.15	0.38	16.37	0.61
01-Jun-87	301.00	302.00	4.72	2135.45	2181.22	462.12	10.76	9.24	0.12	5.32	0.20
23-Mar-87	303.00	305.30	13.57	1632.58	1575.85	116.13	6.88	5.69	0.37	15.65	0.58
23-Mar-87	303.00	308.00	19.23	7850.98	8617.20	448.11	19.85	5.69	1.28	54.89	2.03
14-Apr-87	303.00	308.00	18.16	3451.81	1575.85	86.78	14.24	9.85	0.85	36.54	1.35
23-Mar-87	305.30	306.10	16.75	3365.18	3699.21	220.85	10.56	6.88	0.68	28.98	1.07
29-Jan-87	307.00	306.10	8.97	3365.18	3699.21	412.40	9.95	5.26	0.46	19.78	0.73

Cont.

Table A-2 - cont.

$$J = \frac{(Rn(2) - Rn(1)) \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
12-Mar-87	402.00	401.00	4.11	1287.71	1952.83	475.14	217.70	189.58	3.32	142.04	5.26
14-May-87	402.00	401.00	4.11	1287.71	1952.83	475.14	148.75	154.51	-0.68	-29.10	-1.08
12-Mar-87	403.00	402.00	4.11	1165.55	1788.44	435.14	217.70	151.80	8.60	367.76	13.61
14-May-87	403.00	402.00	4.11	1165.55	1788.44	435.14	148.75	88.08	7.92	338.57	12.53
23-Dec-86	404.00	401.00	4.72	3615.51	5861.16	1241.77	221.55	176.48	2.18	93.18	3.45
14-May-87	404.00	401.00	4.11	3615.51	5861.16	1426.07	154.51	101.16	2.24	96.06	3.55
12-Mar-87	404.00	403.00	4.11	938.49	1463.95	356.19	151.80	175.90	-3.91	-167.02	-6.18
14-May-87	404.00	403.00	4.11	938.49	1463.95	356.19	88.08	101.16	-2.12	-90.65	-3.35
18-Mar-87	405.00	405.10	0.46	390.58	395.83	860.51	399.00	56.73	14.91	638.18	23.61
18-Mar-87	406.00	406.10	0.46	571.46	559.06	1215.36	308.04	180.27	3.81	162.88	6.03
08-Apr-87	408.00	409.00	17.59	500.45	495.13	28.15	46.19	34.27	15.50	662.82	24.52
08-Apr-87	408.00	410.00	17.59	1158.54	1164.38	66.20	40.62	34.27	3.57	152.53	5.64
12-May-87	408.00	410.00	15.80	1158.54	1164.38	73.69	38.60	31.15	3.76	160.74	5.95
12-May-87	408.00	409.00	15.80	500.45	495.13	31.34	34.67	31.15	4.11	175.81	6.51
12-May-87	409.00	410.00	15.80	658.09	669.24	42.36	38.60	34.67	3.49	149.27	5.52
10-Jun-87	412.00	413.00	47.19	1761.14	1819.34	38.55	17.51	16.38	1.12	47.90	1.77
10-Jun-87	412.00	416.00	47.19	2995.52	3037.90	64.38	21.11	16.38	2.76	117.89	4.36
10-Jun-87	413.00	416.00	47.19	1234.38	1218.56	25.82	21.11	17.51	5.09	217.73	8.06
08-Jun-87	415.00	416.00	50.97	731.68	642.15	12.60	27.84	27.18	1.70	72.73	2.69
10-Jun-87	415.00	416.00	47.19	731.68	642.15	13.61	21.11	16.74	10.43	445.87	16.50
09-Jun-87	417.00	417.10	4.78	450.62	403.54	84.42	17.45	16.79	0.26	11.08	0.41
17-Mar-87	501.00	502.00	61.35	5792.87	6266.52	102.14	11.15	4.44	2.63	112.43	4.16
17-Dec-86	504.00	507.00	37.75	6048.76	6793.83	179.97	13.74	7.52	1.44	61.42	2.27
17-Mar-87	504.00	505.00	61.35	2232.73	2494.49	40.66	14.92	11.43	3.55	151.71	5.61
17-Mar-87	504.00	506.00	61.35	4499.89	5252.96	85.62	12.30	7.52	2.41	103.10	3.81
17-Mar-87	505.00	506.00	61.35	2258.73	2738.22	44.63	12.30	14.92	-2.63	-112.58	-4.17
07-Apr-87	508.00	509.00	31.89	5894.23	6737.15	211.26	9.82	9.53	0.06	2.48	0.09

Cont.

Table A-2 - cont.

$$J = \frac{(Rn(2) - Rn(1)) \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
07-Apr-87	510.00	511.00	31.89	5323.17	6105.46	191.45	17.72	12.10	1.25	53.27	1.97
04-Dec-86	601.00	602.00	39.01	3962.11	4847.02	124.25	10.70	10.09	0.22	9.50	0.35
04-Mar-87	601.00	602.10	35.51	5186.74	8597.54	242.12	11.28	11.66	-0.10	-4.12	-0.15
20-Apr-87	601.00	602.10	37.16	5186.74	8597.54	231.37	12.90	11.97	0.25	10.54	0.39
04-Mar-87	601.00	602.20	35.51	5786.36	9348.36	263.26	14.95	11.66	0.75	31.95	1.18
20-Apr-87	601.00	602.20	37.16	5786.36	9348.36	251.57	16.23	11.97	1.01	43.29	1.60
04-Dec-86	601.00	603.00	39.01	7728.98	10207.93	261.67	14.70	10.09	0.86	36.82	1.36
04-Mar-87	601.00	603.00	35.51	7728.98	10207.93	287.47	25.10	11.66	2.28	97.71	3.62
20-Apr-87	601.00	603.00	37.16	7728.98	10207.93	274.70	19.93	11.97	1.42	60.56	2.24
04-Dec-86	602.00	603.00	39.01	3749.44	5307.99	136.07	14.70	10.70	1.54	65.84	2.44
04-Mar-87	602.10	602.20	35.51	620.54	824.43	23.22	14.95	11.28	7.77	332.24	12.29
20-Apr-87	602.10	602.20	37.16	620.54	824.43	22.19	16.23	12.90	7.38	315.47	11.67
04-Mar-87	602.10	603.00	35.51	1136.23	1519.52	42.79	25.10	11.28	15.98	683.30	25.28
20-Apr-87	602.10	603.00	37.16	1136.23	1519.52	40.89	19.93	12.90	8.51	363.73	13.46
04-Mar-87	602.20	603.00	35.51	515.69	695.09	19.57	25.10	14.95	25.86	1105.70	40.91
20-Apr-87	602.20	603.00	37.16	515.69	695.09	18.71	19.93	16.23	9.86	421.79	15.61
16-Dec-86	603.00	604.00	13.21	2064.62	3156.47	238.95	18.72	22.90	-0.99	-42.32	-1.57
15-Dec-86	603.00	605.10	13.63	1825.88	2580.35	189.31	27.39	25.42	0.54	23.27	0.86
10-Dec-86	604.00	606.10	16.52	2005.02	3520.05	213.08	22.62	18.72	1.19	50.84	1.88
16-Dec-86	604.00	606.10	13.21	2005.02	3520.05	266.47	27.02	26.60	0.10	4.38	0.16
26-Jan-87	604.00	606.10	13.52	2005.02	3520.05	260.36	30.89	19.17	2.92	125.05	4.63
30-Apr-87	607.00	608.00	33.51	1585.27	2057.12	61.39	24.00	23.69	0.24	10.37	0.38
13-Apr-87	607.00	609.10	33.51	2579.33	3039.61	90.71	53.27	24.66	13.75	588.06	21.76
09-Dec-86	607.00	610.00	35.92	1130.86	1497.95	41.70	22.01	20.07	2.28	97.49	3.61
13-Apr-87	607.00	610.00	34.92	1130.86	1497.95	42.90	36.57	24.66	13.61	581.82	21.53
09-Dec-86	607.00	611.00	35.92	6687.24	9846.51	274.12	27.81	20.07	1.54	65.79	2.43
30-Apr-87	607.00	611.00	33.51	6824.74	8626.98	257.44	43.02	23.69	3.51	150.18	5.56
08-Dec-86	608.00	609.10	13.21	1010.19	1080.45	81.79	25.11	20.88	2.05	87.51	3.24
19-Jan-87	608.00	609.10	12.74	1010.19	1080.45	84.81	26.63	28.32	-0.79	-33.72	-1.25
30-Apr-87	608.00	611.00	33.51	5219.89	6461.69	192.83	43.02	24.00	4.52	193.20	7.15

Cont.

Table A-2 - cont.

$$J = \frac{(Rn(2) - Rn(1)) \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})} \qquad L = 2.1 \times 10^{-6} + Q/V$$

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Rn(2) RADON GAS FORE STATION (pCi/l)	Rn(1) RADON GAS STATION (pCi/l)	RADON FLUX Bq/m2/s	J pCi/m2/s	J Bq/m2/s
02-Jun-87	608.00	611.00	46.25	5219.89	6461.69	139.71	45.78	25.84	6.54	279.53	10.34
09-Dec-86	610.00	611.00	35.92	3694.73	5158.73	143.62	27.81	22.01	2.09	89.21	3.30
20-Jan-87	613.00	615.10	9.67	4022.35	5117.80	529.25	46.28	36.27	0.89	38.09	1.41
21-Jan-87	613.00	614.10	11.80	4078.12	5204.94	441.10	46.06	40.48	0.60	25.55	0.95
11-Mar-87	613.00	616.00	46.48	5180.14	6291.81	135.37	37.37	36.26	0.37	15.76	0.58
11-Mar-87	613.10	613.00	47.19	1462.30	1676.51	35.53	36.38	36.14	0.29	12.25	0.45
06-May-87	614.00	615.10	10.01	4078.12	5204.94	519.97	47.70	44.04	0.33	14.22	0.53
21-May-87	617.00	617.10	13.71	504.91	511.46	37.31	16.57	16.50	0.07	3.01	0.11
20-May-87	618.00	618.10	16.52	583.73	693.50	41.98	18.56	16.27	2.40	102.53	3.79
13-May-87	620.00	614.10	84.79	4803.69	5685.86	67.06	22.64	50.87	-18.44	-788.33	-29.17
02-Jun-87	621.00	608.00	27.84	3514.37	4925.73	176.93	25.84	26.19	-0.10	-4.39	-0.16
02-Apr-87	701.00	702.10	7.39	949.58	659.04	89.18	25.73	8.36	5.00	213.87	7.91
06-Apr-87	701.00	702.10	7.08	949.58	659.04	93.09	27.72	10.21	4.83	206.55	7.64
10-Mar-87	701.00	703.00	18.88	849.57	814.73	43.15	22.23	10.63	9.54	407.83	15.09
08-Jan-87	703.00	704.10	11.33	1708.43	1809.14	159.68	41.37	24.76	4.08	174.29	6.45
06-Jan-87	705.00	706.10	9.44	824.10	809.80	85.78	48.29	44.05	1.80	76.84	2.84
12-Jan-87	705.00	706.10	9.20	824.10	809.80	88.02	49.80	29.88	8.23	351.83	13.02
14-Jan-87	705.00	706.10	6.13	824.10	809.80	132.11	66.60	39.84	7.36	314.93	11.65
14-Jan-87	705.00	707.00	25.96	442.82	488.78	18.83	43.58	39.84	8.11	346.86	12.83
18-Dec-86	801.00	802.00	76.92	3275.67	3948.11	51.33	98.26	83.31	12.99	555.39	20.55
05-Mar-87	801.00	802.00	70.50	3275.67	3948.11	56.00	91.39	79.03	9.84	420.85	15.57
05-May-87	801.00	802.00	80.13	3275.67	3948.11	49.27	84.46	83.03	1.29	55.34	2.05

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Table A-3

TNFTEMM - THORON FLUX CALCULATED ACCORDING TO THOMAS-EPPS MINE MODEL (TEMM)

(THORON GAS FLUX CALCULATIONS DERIVED FROM WL(Tn) MEASUREMENTS)

$$(1)\ J = \frac{[Tn(2) - Tn(1)] \times Q \times 1000}{S}$$

WHERE: Tn = 500 x WL(Tn)

DATE	LOCATION NUMBER	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL(Tn)	DWL(Tn) x500	J pCi/m2/s	J Bq/m2/s
04-May-87		101.00	102.00	188.77	21798.78	0.01	0.00	0.01	5.00	43.2983	1.602
11-Dec-86		103.00	104.00	206.30	14872.10	0.01	0.02	-0.01	-5.00	-69.3581	-2.566
04-Jun-87		103.00	104.00	212.36	14872.10	0.02	0.01	0.01	5.00	71.3954	2.642
12-Dec-86		202.00	201.00	15.84	6383.38	0.03	0.02	0.01	5.00	12.4072	0.459
01-Apr-87		202.00	201.00	18.88	6383.38	0.02	0.01	0.01	5.00	14.7884	0.547
25-May-87		202.00	201.00	24.07	6383.38	0.01	0.00	0.01	5.00	18.8536	0.698
29-Dec-86		203.00	204.00	19.89	1353.36	0.34	0.28	0.06	30.00	440.9023	16.313
25-Mar-87		203.00	204.00	24.24	1353.36	0.19	0.23	-0.04	-20.00	-358.2193	-13.254
21-Apr-87		203.00	204.00	17.69	1353.36	0.24	0.25	-0.01	-5.00	-65.3558	-2.418
05-Jan-87		205.00	206.00	6.13	5549.63	0.58	0.31	0.27	135.00	149.1181	5.517
26-Mar-87		205.00	206.00	4.96	5549.63	0.28	0.26	0.02	10.00	8.9375	0.331
22-Apr-87		205.00	206.00	1.89	5549.63	0.25	0.27	-0.02	-10.00	-3.4056	-0.126
15-Jan-87		208.00	207.00	54.73	1165.97	0.09	0.08	0.01	5.00	234.6968	8.684
09-Apr-87		208.00	207.00	67.40	1165.97	0.05	0.07	-0.02	-10.00	-578.0582	-21.388
27-May-87		208.00	207.00	63.87	1165.97	0.00	0.00	0.00	0.00	0.0000	0.000
30-Dec-86		209.00	210.00	22.79	830.61	0.03	0.02	0.01	5.00	137.1889	5.076
24-Mar-87		209.00	210.00	21.71	574.81	0.08	0.03	0.05	25.00	944.2305	34.937
30-Mar-87		209.00	209.10	25.77	490.04	0.11	0.05	0.06	30.00	1577.6402	58.373
27-Apr-87		209.00	209.10	23.41	490.04	0.02	0.02	0.00	0.00	0.0000	0.000
28-Apr-87		209.00	209.10	23.50	490.04	0.04	0.04	0.00	0.00	0.0000	0.000
30-Mar-87		209.10	210.00	25.77	340.57	0.09	0.11	-0.02	-10.00	-756.6702	-27.997
27-Apr-87		209.10	210.00	23.41	340.57	0.05	0.02	0.03	15.00	1031.0623	38.149
28-Apr-87		209.10	210.00	23.50	340.57	0.08	0.04	0.04	20.00	1380.0349	51.061
28-Apr-87		210.00	211.00	23.50	560.59	0.07	0.08	-0.01	-5.00	-209.6024	-7.755
22-Dec-86		301.00	302.00	9.44	2135.45	0.10	0.08	0.02	10.00	44.2062	1.636
09-Mar-87		301.00	302.00	9.56	2135.45	0.05	0.03	0.02	10.00	44.7681	1.656
29-Apr-87		301.00	302.00	8.73	2135.45	0.05	0.04	0.01	5.00	20.4407	0.756
01-Jun-87		301.00	302.00	4.72	2135.45	0.05	0.02	0.03	15.00	33.1546	1.227
23-Mar-87		303.00	305.30	13.57	1632.58	0.06	0.04	0.02	10.00	83.1197	3.075
23-Mar-87		303.00	308.00	19.23	7850.98	0.03	0.04	-0.01	-5.00	-12.2469	-0.453
14-Apr-87		303.00	308.00	18.16	3451.81	0.07	0.03	0.04	20.00	105.2200	3.893

Cont.

Table A-3 - cont.

TNFTEMM - THORON FLUX CALCULATED ACCORDING TO THOMAS-EPPS MINE MODEL (TEMM)

THORON GAS FLUX CALCULATIONS DERIVED FROM WL(Tn) MEASUREMENTS

$$(1)\ J = \frac{[Tn(2) - Tn(1)] \times Q \times 1000}{S}$$

WHERE: Tn = 500 x WL(Tn)

DATE	LOCATION NUMBER	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL(Tn)	DWL(Tn) x500	J pCi/m2/s	J Bq/m2/s
23-Mar-87		305.30	306.10	16.75	3365.18	0.06	0.06	0.00	0.00	0.0000	0.000
29-Jan-87		307.00	306.10	8.97	3365.18	0.05	0.03	0.02	10.00	26.6553	0.986
12-Mar-87		402.00	401.00	4.11	1287.71	0.51	0.12	0.39	195.00	622.3839	23.028
14-May-87		402.00	401.00	4.11	1287.71	0.46	0.19	0.27	135.00	430.8812	15.943
12-Mar-87		403.00	402.00	4.11	1165.55	0.51	0.40	0.11	55.00	193.9420	7.176
14-May-87		403.00	402.00	4.11	1165.55	0.46	0.43	0.03	15.00	52.8933	1.957
23-Dec-86		404.00	401.00	4.72	3615.51	0.77	0.62	0.15	75.00	97.9115	3.623
14-May-87		404.00	401.00	4.11	3615.51	0.19	0.26	-0.07	-35.00	-39.7869	-1.472
12-Mar-87		404.00	403.00	4.11	938.49	0.40	0.30	0.10	50.00	218.9677	8.102
14-May-87		404.00	403.00	4.11	938.49	0.43	0.26	0.17	85.00	372.2451	13.773
18-Mar-87		405.00	405.10	0.46	390.58	0.98	0.16	0.82	410.00	482.8735	17.866
18-Mar-87		406.00	406.10	0.46	571.46	0.96	0.48	0.48	240.00	193.1892	7.148
08-Apr-87		408.00	409.00	17.59	500.45	0.11	0.08	0.03	15.00	527.2295	19.507
08-Apr-87		408.00	410.00	17.59	1158.54	0.11	0.08	0.03	15.00	227.7442	8.427
12-May-87		408.00	410.00	15.80	1158.54	0.03	0.03	0.00	0.00	0.0000	0.000
12-May-87		408.00	409.00	15.80	500.45	0.14	0.03	0.11	55.00	1736.4505	64.249
12-May-87		409.00	410.00	15.80	658.09	0.03	0.14	-0.11	-55.00	-1320.4872	-48.858
10-Jun-87		412.00	413.00	47.19	1761.14	0.08	0.10	-0.02	-10.00	-267.9521	-9.914
10-Jun-87		412.00	416.00	47.19	2995.52	0.11	0.10	0.01	5.00	78.7676	2.914
10-Jun-87		413.00	416.00	47.19	1234.38	0.11	0.08	0.03	15.00	573.4438	21.217
08-Jun-87		415.00	416.00	50.97	731.68	0.13	0.12	0.01	5.00	348.3061	12.887
10-Jun-87		415.00	416.00	47.19	731.68	0.11	0.08	0.03	15.00	967.4257	35.795
09-Jun-87		417.00	417.10	4.78	450.62	0.09	0.09	0.00	0.00	0.0000	0.000
17-Mar-87		501.00	502.00	61.35	5792.87	0.06	0.06	0.00	0.00	0.0000	0.000
17-Dec-86		504.00	507.00	37.75	6048.76	0.07	0.08	-0.01	-5.00	-31.2047	-1.155
17-Mar-87		504.00	505.00	61.35	2232.73	0.10	0.06	0.04	20.00	549.5515	20.333

Cont.

Table A-3 - cont.

TNFTENM - THORON FLUX CALCULATED ACCORDING TO THOMAS-EPPS MINE MODEL (TENM)

THORON GAS FLUX CALCULATIONS DERIVED FROM WL(Tn) MEASUREMENTS

$$(1)\ J = \frac{[Tn(2) - Tn(1)] \times Q \times 1000}{S}$$

WHERE: Tn = 500 x WL(Tn)

DATE	LOCATION NUMBER	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL(Tn)	DWL(Tn) x500	J pCi/m2/s	J Bq/m2/s
17-Mar-87		504.00	506.00	61.35	4499.89	0.11	0.08	0.03	15.00	204.5051	7.567
17-Mar-87		505.00	506.00	61.35	2258.73	0.11	0.10	0.01	5.00	135.8065	5.025
07-Apr-87		508.00	509.00	31.89	5894.23	0.06	0.05	0.01	5.00	27.0519	1.001
07-Apr-87		510.00	511.00	31.89	5323.17	0.07	0.04	0.03	15.00	89.8619	3.325
04-Dec-86		601.00	602.00	39.01	3962.11	0.05	0.06	-0.01	-5.00	-49.2288	-1.821
04-Mar-87		601.00	602.10	35.51	5186.74	0.03	0.04	-0.01	-5.00	-34.2315	-1.267
20-Apr-87		601.00	602.10	37.16	5186.74	0.11	0.03	0.08	40.00	286.5770	10.603
04-Mar-87		601.00	602.20	35.51	5786.36	0.04	0.04	0.00	0.00	0.0000	0.000
20-Apr-87		601.00	602.20	37.16	5786.36	0.10	0.03	0.07	35.00	224.7699	8.316
04-Dec-86		601.00	603.00	39.01	7728.98	0.13	0.06	0.07	35.00	176.6532	6.536
04-Mar-87		601.00	603.00	35.51	7728.98	0.08	0.04	0.04	20.00	91.8879	3.400
20-Apr-87		601.00	603.00	37.16	7728.98	0.11	0.03	0.08	40.00	192.3151	7.116
04-Dec-86		602.00	603.00	39.01	3749.44	0.13	0.05	0.08	40.00	416.1686	15.398
04-Mar-87		602.10	602.20	35.51	620.54	0.04	0.03	0.01	5.00	286.1225	10.587
20-Apr-87		602.10	602.20	37.16	620.54	0.10	0.11	-0.01	-5.00	-299.4174	-11.078
04-Mar-87		602.10	603.00	35.51	1136.23	0.08	0.03	0.05	25.00	781.3130	28.909
20-Apr-87		602.10	603.00	37.16	1136.23	0.11	0.11	0.00	0.00	0.0000	0.000
04-Mar-87		602.20	603.00	35.51	515.69	0.08	0.04	0.04	20.00	1377.1838	50.956
20-Apr-87		602.20	603.00	37.16	515.69	0.11	0.10	0.01	5.00	360.2939	13.331
16-Dec-86		603.00	604.00	13.21	2064.62	0.15	0.16	-0.01	-5.00	-31.9914	-1.184
15-Dec-86		603.00	605.10	13.63	1825.88	0.12	0.12	0.00	0.00	0.0000	0.000
10-Dec-86		604.00	606.10	16.52	2005.02	0.12	0.15	-0.03	-15.00	-123.5898	-4.573
16-Dec-86		604.00	606.10	13.21	2005.02	0.10	0.13	-0.03	-15.00	-98.8270	-3.657
26-Jan-87		604.00	606.10	13.52	2005.02	0.14	0.16	-0.02	-10.00	-67.4308	-2.495
30-Apr-87		607.00	608.00	33.51	1585.27	0.07	0.07	0.00	0.00	0.0000	0.000
13-Apr-87		607.00	609.10	33.51	2579.33	0.17	0.09	0.08	40.00	519.6692	19.228
09-Dec-86		607.00	610.00	35.92	1130.86	0.13	0.11	0.02	10.00	317.6334	11.752

Cont.

Table A-3 - cont.

TMFTEMM - THORON FLUX CALCULATED ACCORDING TO THOMAS-EPPS MINE MODEL (TEMM)

THORON GAS FLUX CALCULATIONS DERIVED FROM WL(Tn) MEASUREMENTS

$$(1)\ J = \frac{[Tn(2) - Tn(1)] \times Q \times 1000}{S}$$

WHERE: Tn = 500 x WL(Tn)

DATE	LOCATION NUMBER	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL(Tn)	DWL(Tn) x500	J pCi/m2/s	J Bq/m2/s
13-Apr-87		607.00	610.00	34.92	1130.86	0.10	0.09	0.01	5.00	154.3953	5.713
09-Dec-86		607.00	611.00	35.92	6687.24	0.15	0.11	0.04	20.00	107.4285	3.975
30-Apr-87		607.00	611.00	33.51	6824.74	0.25	0.07	0.18	90.00	441.9068	16.351
08-Dec-86		608.00	609.10	13.21	1010.19	0.14	0.14	0.00	0.00	0.0000	0.000
19-Jan-87		608.00	609.10	12.74	1010.19	0.15	0.13	0.02	10.00	126.1152	4.666
30-Apr-87		608.00	611.00	33.51	5219.89	0.25	0.07	0.18	90.00	577.7704	21.378
02-Jun-87		608.00	611.00	46.25	5219.89	0.36	0.14	0.22	110.00	974.6368	36.062
09-Dec-86		610.00	611.00	35.92	3694.73	0.15	0.13	0.02	10.00	97.2196	3.597
20-Jan-87		613.00	615.10	9.67	4022.35	0.20	0.16	0.04	20.00	48.0814	1.779
21-Jan-87		613.00	614.10	11.80	4078.12	0.09	0.18	-0.09	-45.00	-130.2072	-4.818
11-Mar-87		613.00	616.00	46.48	5180.14	0.18	0.17	0.01	5.00	44.8637	1.660
11-Mar-87		613.10	613.00	47.19	1462.30	0.17	0.17	0.00	0.00	0.0000	0.000
06-May-87		614.00	615.10	10.01	4078.12	0.23	0.22	0.01	5.00	12.2728	0.454
21-May-87		617.00	617.10	13.71	504.91	0.13	0.12	0.01	5.00	135.7674	5.023
20-May-87		618.00	618.10	16.52	583.73	0.08	0.11	-0.03	-15.00	-424.5114	-15.707
13-May-87		620.00	614.10	84.79	4803.69	0.18	0.16	0.02	10.00	176.5102	6.531
02-Jun-87		621.00	608.00	27.84	3514.37	0.14	0.10	0.04	20.00	158.4352	5.862
02-Apr-87		701.00	702.10	7.39	949.58	0.08	0.06	0.02	10.00	77.8236	2.879
06-Apr-87		701.00	702.10	7.08	949.58	0.04	0.01	0.03	15.00	111.8385	4.138
10-Mar-87		701.00	703.00	18.88	849.57	0.11	0.05	0.06	30.00	666.6912	24.668
08-Jan-87		703.00	704.10	11.33	1708.43	0.09	0.07	0.02	10.00	66.3181	2.454
06-Jan-87		705.00	706.10	9.44	824.10	0.13	0.13	0.00	0.00	0.0000	0.000
12-Jan-87		705.00	706.10	9.20	824.10	0.08	0.07	0.01	5.00	55.8185	2.065
14-Jan-87		705.00	706.10	6.13	824.10	0.08	0.09	-0.01	-5.00	-37.1921	-1.376
14-Jan-87		705.00	707.00	25.96	442.82	0.09	0.09	0.00	0.00	0.0000	0.000
18-Dec-86		801.00	802.00	76.92	3275.67	0.57	0.48	0.09	45.00	1056.6989	39.098
05-Mar-87		801.00	802.00	70.50	3275.67	0.37	0.36	0.01	5.00	107.6115	3.982

Cont.

Table A-3 - cont.

TNFTEMM - THORON FLUX CALCULATED ACCORDING TO THOMAS-EPPS MINE MODEL (TEMM)

THORON GAS FLUX CALCULATIONS DERIVED FROM WL(Tn) MEASUREMENTS

$$(1)\ J = \frac{[Tn(2) - Tn(1)] \times Q \times 1000}{S}$$

WHERE: Tn = 500 x WL(Tn)

DATE	LOCATION NUMBER	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL(Tn)	DWL(Tn) x500	J pCi/m2/s	J Bq/m2/s
05-May-87		801.00	802.00	80.13	3275.67	0.36	0.39	-0.03	-15.00	-366.9322	-13.576

Table A-4 - Thoron flux calculated according to the modified Thomas-Epps mine model (MTEMM). Also shown are other data of interest.

(THORON GAS FLUX CALCULATIONS, DERIVED FROM WL(Tn) MEASUREMENTS.)

$$J = \frac{[Tn(2)-Tn(1)] \times V \times I \times 1000}{S \times (1 - e^{(-1 \times t)})}$$

WHERE; Tn = 500 X WL(Tn) , I = 0.693 / 54.5

			Q	S	V	t	Tn(2)	Tn(1)					
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL	DWL x500 pCi/l	DWL x500x1000 pCi/m3	J pCi/m2/s	J Bq/m2/s
04-May-87	101.00	102.00	188.77	21798.78	36552.83	193.64	0.01	0.00	0.01	5.00	5000.00	116.54	4.31
11-Dec-86	103.00	104.00	206.30	14872.10	28338.61	137.37	0.01	0.02	-0.01	-5.00	-5000.00	-146.73	-5.43
04-Jun-87	103.00	104.00	212.36	14872.10	28338.61	133.45	0.02	0.01	0.01	5.00	5000.00	148.33	5.49
12-Dec-86	202.00	201.00	15.84	6383.38	8133.18	513.46	0.03	0.02	0.01	5.00	5000.00	81.12	3.00
01-Apr-87	202.00	201.00	18.88	6383.38	8133.18	430.78	0.02	0.01	0.01	5.00	5000.00	81.35	3.01
25-May-87	202.00	201.00	24.07	6383.38	8133.18	337.90	0.01	0.00	0.01	5.00	5000.00	82.12	3.04
29-Dec-86	203.00	204.00	19.89	1353.36	1333.05	67.02	0.34	0.28	0.06	30.00	30000.00	655.14	24.24
25-Mar-87	203.00	204.00	24.24	1353.36	1333.05	54.99	0.19	0.23	-0.04	-20.00	-20000.00	-497.95	-18.42
21-Apr-87	203.00	204.00	17.69	1353.36	1333.05	75.36	0.24	0.25	-0.01	-5.00	-5000.00	-101.59	-3.76
05-Jan-87	205.00	206.00	6.13	5549.63	6481.97	1057.42	0.58	0.31	0.27	135.00	135000.00	2005.00	74.18
26-Mar-87	205.00	206.00	4.96	5549.63	6481.97	1306.85	0.28	0.26	0.02	10.00	10000.00	148.52	5.50
22-Apr-87	205.00	206.00	1.89	5549.63	6481.97	3429.61	0.25	0.27	-0.02	-10.00	-10000.00	-148.52	-5.50
15-Jan-87	208.00	207.00	54.73	1165.97	1104.53	20.18	0.09	0.08	0.01	5.00	5000.00	266.10	9.85
09-Apr-87	208.00	207.00	67.40	1165.97	1104.53	16.39	0.05	0.07	-0.02	-10.00	-10000.00	-640.38	-23.69
27-May-87	208.00	207.00	63.87	1165.97	1104.53	17.29	0.00	0.00	0.00	0.00	0.00	0.00	0.00
30-Dec-86	209.00	210.00	22.79	830.61	788.95	34.62	0.03	0.02	0.01	5.00	5000.00	169.59	6.27
24-Mar-87	209.00	210.00	21.71	574.81	321.02	14.79	0.08	0.03	0.05	25.00	25000.00	1035.78	38.32
30-Mar-87	209.00	209.10	25.77	490.04	467.93	18.16	0.11	0.05	0.06	30.00	30000.00	1766.77	65.37
27-Apr-87	209.00	209.10	23.41	490.04	467.93	19.99	0.02	0.02	0.00	0.00	0.00	0.00	0.00
28-Apr-87	209.00	209.10	23.50	490.04	467.93	19.91	0.04	0.04	0.00	0.00	0.00	0.00	0.00
30-Mar-87	209.10	210.00	25.77	340.57	321.02	12.46	0.09	0.11	-0.02	-10.00	-10000.00	-818.18	-30.27
27-Apr-87	209.10	210.00	23.41	340.57	321.02	13.71	0.05	0.02	0.03	15.00	15000.00	1123.57	41.57
28-Apr-87	209.10	210.00	23.50	340.57	321.02	13.66	0.08	0.04	0.04	20.00	20000.00	1503.36	55.62
28-Apr-87	210.00	211.00	23.50	560.59	673.33	28.65	0.07	0.08	-0.01	-5.00	-5000.00	-250.10	-9.25
22-Dec-86	301.00	302.00	9.44	2135.45	2181.22	231.06	0.10	0.08	0.02	10.00	10000.00	137.15	5.07
09-Mar-87	301.00	302.00	9.56	2135.45	2181.22	228.16	0.05	0.03	0.02	10.00	10000.00	137.43	5.09
29-Apr-87	301.00	302.00	8.73	2135.45	2181.22	249.85	0.05	0.04	0.01	5.00	5000.00	67.77	2.51
01-Jun-87	301.00	302.00	4.72	2135.45	2181.22	462.12	0.05	0.02	0.03	15.00	15000.00	195.37	7.23
23-Mar-87	303.00	305.30	13.57	1632.58	1575.85	116.13	0.06	0.04	0.02	10.00	10000.00	159.07	5.89

Cont.

Table A-4 - cont.

THORON GAS FLUX CALCULATIONS, DERIVED FROM WL(Tn) MEASUREMENTS.

$$J = \frac{[Tn(2)-Tn(1)] \times V \times I \times 1000}{S \times (1 - e^{(-1 \times t)})}$$

WHERE; Tn = 500 X WL(Tn) , I = 0.693 / 54.5

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	Tn(2) THORON FORE STATION (w.l.)	Tn(1) THORON STATION (w.l.)	DWL	DWL x500 pCi/l	DWL x500x1000 pCi/m3	J pCi/m2/s	J Bq/m2/s
23-Mar-87	303.00	308.00	19.23	7850.98	8617.20	448.11	0.03	0.04	-0.01	-5.00	-5000.00	-70.02	-2.59
14-Apr-87	303.00	308.00	18.16	3451.81	1575.85	86.78	0.07	0.03	0.04	20.00	20000.00	173.74	6.43
23-Mar-87	305.30	306.10	16.75	3365.18	3699.21	220.85	0.06	0.06	0.00	0.00	0.00	0.00	0.00
29-Jan-87	307.00	306.10	8.97	3365.18	3699.21	412.40	0.05	0.03	0.02	10.00	10000.00	140.52	5.20
12-Mar-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.51	0.12	0.39	195.00	195000.00	3769.23	139.46
14-May-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.46	0.19	0.27	135.00	135000.00	2609.47	96.55
12-Mar-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.51	0.40	0.11	55.00	55000.00	1077.36	39.86
14-May-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.46	0.43	0.03	15.00	15000.00	293.83	10.87
23-Dec-86	404.00	401.00	4.72	3615.51	5861.16	1241.77	0.77	0.62	0.15	75.00	75000.00	1546.01	57.20
14-May-87	404.00	401.00	4.11	3615.51	5861.16	1426.07	0.19	0.26	-0.07	-35.00	-35000.00	-721.47	-26.69
12-Mar-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.40	0.30	0.10	50.00	50000.00	1002.56	37.09
14-May-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.43	0.26	0.17	85.00	85000.00	1704.36	63.06
18-Mar-87	405.00	405.10	0.46	390.58	395.83	860.51	0.98	0.16	0.82	410.00	410000.00	5283.63	195.49
18-Mar-87	406.00	406.10	0.46	571.46	559.06	1215.36	0.96	0.48	0.48	240.00	240000.00	2985.54	110.47
08-Apr-87	408.00	409.00	17.59	500.45	495.13	28.15	0.11	0.08	0.03	15.00	15000.00	627.20	23.21
08-Apr-87	408.00	410.00	17.59	1158.54	1164.38	66.20	0.11	0.08	0.03	15.00	15000.00	336.88	12.46
12-May-87	408.00	410.00	15.80	1158.54	1164.38	73.69	0.03	0.03	0.00	0.00	0.00	0.00	0.00
12-May-87	408.00	409.00	15.80	500.45	495.13	31.34	0.14	0.03	0.11	55.00	55000.00	2105.33	77.90
12-May-87	409.00	410.00	15.80	658.09	669.24	42.36	0.03	0.14	-0.11	-55.00	-55000.00	-1707.86	-63.19
10-Jun-87	412.00	413.00	47.19	1761.14	1819.34	38.55	0.08	0.10	-0.02	-10.00	-10000.00	-338.98	-12.54
10-Jun-87	412.00	416.00	47.19	2995.52	3037.90	64.38	0.11	0.10	0.01	5.00	5000.00	115.36	4.27
10-Jun-87	413.00	416.00	47.19	1234.38	1218.56	25.82	0.11	0.08	0.03	15.00	15000.00	672.73	24.89
08-Jun-87	415.00	416.00	50.97	731.68	642.15	12.60	0.13	0.12	0.01	5.00	5000.00	376.95	13.95
10-Jun-87	415.00	416.00	47.19	731.68	642.15	13.61	0.11	0.08	0.03	15.00	15000.00	1053.54	38.98
09-Jun-87	417.00	417.10	4.78	450.62	403.54	84.42	0.09	0.09	0.00	0.00	0.00	0.00	0.00

Cont.

Table A-4 - cont.

THORON GAS FLUX CALCULATIONS, DERIVED FROM WL(Tn) MEASUREMENTS.

$$J = \frac{[Tn(2)-Tn(1)] \times V \times I \times 1000}{S \times (1 - e^{(-1 \times t)})}$$

WHERE; Tn = 500 X WL(Tn) , I = 0.693 / 54.5

			Q	S	V	t	Tn(2)	Tn(1)					
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL	DWL x500 pCi/l	DWL x500x1000 pCi/m3	J pCi/m2/s	J Bq/m2/s
17-Mar-87	501.00	502.00	61.35	5792.87	6266.52	102.14	0.06	0.06	0.00	0.00	0.00	0.00	0.00
17-Dec-86	504.00	507.00	37.75	6048.76	6793.83	179.97	0.07	0.08	-0.01	-5.00	-5000.00	-79.47	-2.94
17-Mar-87	504.00	505.00	61.35	2232.73	2494.49	40.66	0.10	0.06	0.04	20.00	20000.00	703.80	26.04
17-Mar-87	504.00	506.00	61.35	4499.89	5252.96	85.62	0.11	0.08	0.03	15.00	15000.00	335.64	12.42
17-Mar-87	505.00	506.00	61.35	2258.73	2738.22	44.63	0.11	0.10	0.01	5.00	5000.00	177.97	6.58
07-Apr-87	508.00	509.00	31.89	5894.23	6737.15	211.26	0.06	0.05	0.01	5.00	5000.00	77.98	2.89
07-Apr-87	510.00	511.00	31.89	5323.17	6105.46	191.45	0.07	0.04	0.03	15.00	15000.00	239.78	8.87
04-Dec-86	601.00	602.00	39.01	3962.11	4847.02	124.25	0.05	0.06	-0.01	-5.00	-5000.00	-97.96	-3.62
04-Mar-87	601.00	602.10	35.51	5186.74	6597.54	242.12	0.03	0.04	-0.01	-5.00	-5000.00	-110.47	-4.09
20-Apr-87	601.00	602.10	37.16	5186.74	6597.54	231.37	0.11	0.03	0.08	40.00	40000.00	890.06	32.93
04-Mar-87	601.00	602.20	35.51	5786.36	9348.36	263.26	0.04	0.04	0.00	0.00	0.00	0.00	0.00
20-Apr-87	601.00	602.20	37.16	5786.36	9348.36	251.57	0.10	0.03	0.07	35.00	35000.00	749.60	27.74
04-Dec-86	601.00	603.00	39.01	7728.98	10207.93	261.67	0.13	0.06	0.07	35.00	35000.00	609.67	22.56
04-Mar-87	601.00	603.00	35.51	7728.98	10207.93	287.47	0.0[illegible]	0.04	0.04	20.00	20000.00	344.79	12.76
20-Apr-87	601.00	603.00	37.16	7728.98	10[illegible]7.93	274.70	0.11	0.03	0.08	40.00	40000.00	692.83	25.63
04-Dec-86	602.00	603.00	39.01	3749.44	5307.99	136.07	0.13	0.05	0.08	40.00	40000.00	875.17	32.38
04-Mar-87	602.10	602.20	35.51	620.54	824.43	23.22	0.04	0.03	0.01	5.00	5000.00	330.43	12.23
20-Apr-87	602.10	602.20	37.16	620.54	824.43	22.19	0.10	0.11	-0.01	-5.00	-5000.00	-343.63	-12.71
04-Mar-87	602.10	603.00	35.51	1136.23	1519.52	42.79	0.08	0.03	0.05	25.00	25000.00	1013.06	37.48
20-Apr-87	602.10	603.00	37.16	1136.23	1519.52	40.89	0.11	0.11	0.00	0.00	0.00	0.00	0.00
04-Mar-87	602.20	603.00	35.51	515.69	695.09	19.57	0.08	0.04	0.04	20.00	20000.00	1555.68	57.56
20-Apr-87	602.20	603.00	37.16	515.69	695.09	18.71	0.11	0.10	0.01	5.00	5000.00	404.84	14.98
16-Dec-86	603.00	604.00	13.21	2064.62	3156.47	238.95	0.15	0.16	-0.01	-5.00	-5000.00	-102.09	-3.78
15-Dec-86	603.00	605.10	13.63	1825.88	2580.35	189.31	0.12	0.12	0.00	0.00	0.00	0.00	0.00

Cont.

Table A-4 - cont.

THORON GAS FLUX CALCULATIONS, DERIVED FROM WL(Tn) MEASUREMENTS.

$$J = \frac{[Tn(2)-Tn(1)] \times V \times I \times 1000}{S \times (1 - e^{(-1 \times t)})}$$

WHERE: Tn = 500 X WL(Tn) , I = 0.693 / 54.5

			Q	S	V	t	Tn(2)	Tn(1)					
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL	DWL x500 pCi/l	DWL x500x1000 pCi/m3	J pCi/m2/s	J Bq/m2/s
10-Dec-86	604.00	606.10	16.52	2005.02	3520.05	213.08	0.12	0.15	-0.03	-15.00	-15000.00	-358.74	-13.27
16-Dec-86	604.00	606.10	13.21	2005.02	3520.05	266.47	0.10	0.13	-0.03	-15.00	-15000.00	-346.56	-12.82
26-Jan-87	604.00	606.10	13.52	2005.02	3520.05	260.36	0.14	0.16	-0.02	-10.00	-10000.00	-231.69	-8.57
30-Apr-87	607.00	608.00	33.51	1585.27	2057.12	61.39	0.07	0.07	0.00	0.00	0.00	0.00	0.00
13-Apr-87	607.00	609.10	33.51	2579.33	3039.61	90.71	0.17	0.09	0.08	40.00	40000.00	875.73	32.40
09-Dec-86	607.00	610.00	35.92	1130.86	1497.95	41.70	0.13	0.11	0.02	10.00	10000.00	409.26	15.14
13-Apr-87	607.00	610.00	34.92	1130.86	1497.95	42.90	0.10	0.09	0.01	5.00	5000.00	200.31	7.41
09-Dec-86	607.00	611.00	35.92	6687.24	9846.51	274.12	0.15	0.11	0.04	20.00	20000.00	386.29	14.29
30-Apr-87	607.00	611.00	33.51	6824.74	8626.98	257.44	0.25	0.07	0.18	90.00	90000.00	1503.55	55.63
08-Dec-86	608.00	609.10	13.21	1010.19	1080.45	81.79	0.14	0.14	0.00	0.00	0.00	0.00	0.00
19-Jan-87	608.00	609.10	12.74	1010.19	1080.45	84.81	0.15	0.13	0.02	10.00	10000.00	206.11	7.63
30-Apr-87	608.00	611.00	33.51	5219.89	6461.69	192.83	0.25	0.07	0.18	90.00	90000.00	1550.16	57.36
02-Jun-87	608.00	611.00	46.25	5219.89	6461.69	139.71	0.36	0.14	0.22	110.00	110000.00	2084.16	77.11
09-Dec-86	610.00	611.00	35.92	3694.73	5158.73	143.62	0.15	0.13	0.02	10.00	10000.00	211.62	7.83
20-Jan-87	613.00	615.10	9.67	4022.35	5117.80	529.25	0.20	0.16	0.04	20.00	20000.00	323.96	11.99
21-Jan-87	613.00	614.10	11.80	4078.12	5204.94	441.10	0.09	0.18	-0.09	-45.00	-45000.00	-732.99	-27.12
11-Mar-87	613.00	616.00	46.48	5180.14	6291.81	135.37	0.18	0.17	0.01	5.00	5000.00	94.04	3.48
11-Mar-87	613.10	613.00	47.19	1462.30	1676.51	35.53	0.17	0.17	0.00	0.00	0.00	0.00	0.00
06-May-87	614.00	615.10	10.01	4078.12	5204.94	519.97	0.23	0.22	0.01	5.00	5000.00	81.25	3.01
21-May-87	617.00	617.10	13.71	504.91	511.46	37.31	0.13	0.12	0.01	5.00	5000.00	170.50	6.31
20-May-87	618.00	618.10	16.52	583.73	693.50	41.98	0.08	0.11	-0.03	-15.00	-15000.00	-547.84	-20.27
13-May-87	620.00	614.10	84.79	4803.69	5685.86	67.06	0.18	0.16	0.02	10.00	10000.00	262.33	9.71
02-Jun-87	621.00	608.00	27.84	3514.37	4925.73	176.93	0.14	0.10	0.04	20.00	20000.00	398.45	14.74
02-Apr-87	701.00	702.10	7.39	949.58	659.04	89.18	0.08	0.06	0.02	10.00	10000.00	130.11	4.81
06-Apr-87	701.00	702.10	7.08	949.58	659.04	93.09	0.04	0.01	0.03	15.00	15000.00	190.79	7.06

Cont.

Table A-4 - cont.

THORON GAS FLUX CALCULATIONS, DERIVED FROM WL(Tn) MEASUREMENTS.

$$J = \frac{[Tn(2)-Tn(1)] \times V \times I \times 1000}{S \times (1 - e^{(-1 \times t)})}$$

WHERE; Tn = 500 X WL(Tn) , I = 0.693 / 54.5

			Q	S	V	t	Tn(2)	Tn(1)					
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	DWL	DWL x500 pCi/l	DWL x500x1000 pCi/m3	J pCi/m2/s	J Bq/m2/s
10-Mar-87	701.00	703.00	18.88	849.57	814.73	43.15	0.11	0.05	0.06	30.00	30000.00	866.25	32.05
08-Jan-87	703.00	704.10	11.33	1708.43	1809.14	159.68	0.09	0.07	0.02	10.00	10000.00	155.00	5.74
06-Jan-87	705.00	706.10	9.44	824.10	809.80	85.78	0.13	0.13	0.00	0.00	0.00	0.00	0.00
12-Jan-87	705.00	706.10	9.20	824.10	809.80	88.02	0.08	0.07	0.01	5.00	5000.00	92.76	3.43
14-Jan-87	705.00	706.10	6.13	824.10	809.80	132.11	0.08	0.09	-0.01	-5.00	-5000.00	-76.79	-2.84
14-Jan-87	705.00	707.00	25.96	442.82	408.78	18.83	0.09	0.09	0.00	0.00	0.00	0.00	0.00
18-Dec-86	801.00	802.00	76.92	3275.67	3948.11	51.33	0.57	0.48	0.09	45.00	45000.00	1438.78	53.23
05-Mar-87	801.00	802.00	70.50	3275.67	3948.11	56.00	0.37	0.36	0.01	5.00	5000.00	150.44	5.57
05-May-87	801.00	802.00	80.13	3275.67	3948.11	49.27	0.36	0.39	-0.03	-15.00	-15000.00	-493.80	-18.27

Table A-5 - Thoron flux calculated according to Eq. 15.
Also shown are other data of interest.

$$J = \frac{[Tn(2) - Tn(1) \times e^{(-L \times t)}] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

			Q	S	V	t				
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
04-May-87	101.00	102.00	188.77	21798.78	36552.83	193.64	0.01	0.00	154.76	5.73
11-Dec-86	103.00	104.00	206.30	14872.10	28338.61	137.37	0.01	0.02	177.45	6.57
04-Jun-87	103.00	104.00	212.36	14872.10	28338.61	133.45	0.02	0.01	399.00	14.76
12-Dec-86	202.00	201.00	15.84	6383.38	8133.18	513.46	0.03	0.02	280.29	10.37
01-Apr-87	202.00	201.00	18.88	6383.38	8133.18	430.78	0.02	0.01	191.74	7.09
25-May-87	202.00	201.00	24.07	6383.38	8133.18	337.90	0.01	0.00	100.36	3.71
29-Dec-86	203.00	204.00	19.89	1353.36	1333.05	67.02	0.34	0.28	4779.62	176.85
25-Mar-87	203.00	204.00	24.24	1353.36	1333.05	54.99	0.19	0.23	2755.21	101.94
21-Apr-87	203.00	204.00	17.69	1353.36	1333.05	75.36	0.24	0.25	3050.48	112.87
05-Jan-87	205.00	206.00	6.13	5549.63	6481.97	1057.42	0.58	0.31	4627.36	171.21
26-Mar-87	205.00	206.00	4.96	5549.63	6481.97	1306.85	0.28	0.26	2204.38	81.56
22-Apr-87	205.00	206.00	1.89	5549.63	6481.97	3429.61	0.25	0.27	1899.05	70.26
15-Jan-87	208.00	207.00	54.73	1165.97	1104.53	20.18	0.09	0.08	2771.65	102.55
09-Apr-87	208.00	207.00	67.40	1165.97	1104.53	16.39	0.05	0.07	1448.80	53.61
27-May-87	208.00	207.00	63.87	1165.97	1104.53	17.29	0.00	0.00	0.00	0.00
30-Dec-86	209.00	210.00	22.79	830.61	788.95	34.62	0.03	0.02	654.07	24.20
24-Mar-87	209.00	210.00	21.71	574.81	321.02	14.79	0.08	0.03	2286.70	84.61
30-Mar-87	209.00	209.10	25.77	490.04	467.93	18.16	0.11	0.05	4361.17	161.36
27-Apr-87	209.00	209.10	23.41	490.04	467.93	19.99	0.02	0.02	599.14	22.17
28-Apr-87	209.00	209.10	23.50	490.04	467.93	19.91	0.04	0.04	1201.95	44.47
30-Mar-87	209.10	210.00	25.77	340.57	321.02	12.46	0.09	0.11	3543.18	131.10
27-Apr-87	209.10	210.00	23.41	340.57	321.02	13.71	0.05	0.02	2559.58	94.70
28-Apr-87	209.10	210.00	23.50	340.57	321.02	13.66	0.08	0.04	3964.56	146.69
28-Apr-87	210.00	211.00	23.50	560.59	673.33	28.65	0.07	0.08	1903.60	70.43
22-Dec-86	301.00	302.00	9.44	2135.45	2181.22	231.06	0.10	0.08	873.90	32.33
09-Mar-87	301.00	302.00	9.56	2135.45	2181.22	228.16	0.05	0.03	440.23	16.29
29-Apr-87	301.00	302.00	8.73	2135.45	2181.22	249.85	0.05	0.04	428.24	15.84
01-Jun-87	301.00	302.00	4.72	2135.45	2181.22	462.12	0.05	0.02	380.20	14.07
23-Mar-87	303.00	305.30	13.57	1632.58	1575.85	116.13	0.06	0.04	636.46	23.55
23-Mar-87	303.00	308.00	19.23	7850.98	8617.20	448.11	0.03	0.04	245.99	9.10
14-Apr-87	303.00	308.00	18.16	3451.81	1575.85	86.78	0.07	0.03	418.08	15.47
23-Mar-87	305.30	306.10	16.75	3365.18	3699.21	220.85	0.06	0.06	568.66	21.04

Cont.

Table A-5 - cont.

$$J = \frac{[Tn(2) - Tn(1) \times e^{(-L \times t)}] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
29-Jan-87	307.00	306.10	8.97	3365.18	3699.21	412.40	0.05	0.03	416.41	15.41
12-Mar-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.51	0.12	5735.00	212.19
14-May-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.46	0.19	5171.94	191.36
12-Mar-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.51	0.40	5876.34	217.42
14-May-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.46	0.43	5299.06	196.07
23-Dec-86	404.00	401.00	4.72	3615.51	5861.16	1241.77	0.77	0.62	8438.79	312.24
14-May-87	404.00	401.00	4.11	3615.51	5861.16	1426.07	0.19	0.26	2066.27	76.45
12-Mar-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.40	0.30	4847.69	179.36
14-May-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.43	0.26	5214.28	192.93
18-Mar-87	405.00	405.10	0.46	390.58	395.83	860.51	0.98	0.16	6891.60	254.99
18-Mar-87	406.00	406.10	0.46	571.46	559.06	1215.36	0.96	0.48	6357.46	235.23
08-Apr-87	408.00	409.00	17.59	500.45	495.13	28.15	0.11	0.08	2873.00	106.30
08-Apr-87	408.00	410.00	17.59	1158.54	1164.38	66.20	0.11	0.08	1616.98	59.83
12-May-87	408.00	410.00	15.80	1158.54	1164.38	73.69	0.03	0.03	396.26	14.66
12-May-87	408.00	409.00	15.80	500.45	495.13	31.34	0.14	0.03	3887.12	143.82
12-May-87	409.00	410.00	15.80	658.09	669.24	42.36	0.03	0.14	-1.30	-0.05
10-Jun-87	412.00	413.00	47.19	1761.14	1819.34	38.55	0.08	0.10	1481.10	54.80
10-Jun-87	412.00	416.00	47.19	2995.52	3037.90	64.38	0.11	0.10	1603.44	59.33
10-Jun-87	413.00	416.00	47.19	1234.38	1218.56	25.82	0.11	0.08	3067.54	113.50
08-Jun-87	415.00	416.00	50.97	731.68	642.15	12.60	0.13	0.12	5437.83	201.20
10-Jun-87	415.00	416.00	47.19	731.68	642.15	13.61	0.11	0.08	4669.49	172.77
09-Jun-87	417.00	417.10	4.78	450.62	403.54	84.42	0.09	0.09	989.75	36.62
17-Mar-87	501.00	502.00	61.35	5792.87	6266.52	102.14	0.06	0.06	730.38	27.02
17-Dec-86	504.00	507.00	37.75	6048.76	6793.83	179.97	0.07	0.08	714.32	26.43
17-Mar-87	504.00	505.00	61.35	2232.73	2494.49	40.66	0.10	0.06	2318.47	85.78
17-Mar-87	504.00	506.00	61.35	4499.89	5252.96	85.62	0.11	0.08	1626.63	60.19

Cont.

Table A-5 - cont.

$$J = \frac{[Tn(2) - Tn(1) \times e^{(-L \times t)}] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
17-Mar-87	505.00	506.00	61.35	2258.73	2738.22	44.63	0.11	0.10	2397.79	88.72
07-Apr-87	508.00	509.00	31.89	5894.23	6737.15	211.26	0.06	0.05	600.90	22.23
07-Apr-87	510.00	511.00	31.89	5323.17	6105.46	191.45	0.07	0.04	730.41	27.03
04-Dec-86	601.00	602.00	39.01	3962.11	4847.02	124.25	0.05	0.06	624.62	23.11
04-Mar-87	601.00	602.10	35.51	5186.74	8597.54	242.12	0.03	0.04	416.45	15.41
20-Apr-87	601.00	602.10	37.16	5186.74	8597.54	231.37	0.11	0.03	1575.66	58.30
04-Mar-87	601.00	602.20	35.51	5786.36	9348.36	263.26	0.04	0.04	533.60	19.74
20-Apr-87	601.00	602.20	37.16	5786.36	9348.36	251.57	0.10	0.07	1362.64	50.42
04-Dec-86	601.00	603.00	39.01	7728.98	10207.93	261.67	0.13	0.06	1429.90	52.91
04-Mar-87	601.00	603.00	35.51	7728.98	10207.93	287.47	0.08	0.04	859.64	31.81
20-Apr-87	601.00	603.00	37.16	7728.98	10207.93	274.70	0.11	0.03	1197.87	44.32
04-Dec-86	602.00	603.00	39.01	3749.44	5307.99	136.07	0.13	0.05	1925.61	71.25
04-Mar-87	602.10	602.20	35.51	620.54	824.43	23.22	0.04	0.03	1622.11	60.02
20-Apr-87	602.10	602.20	37.16	620.54	824.43	22.19	0.10	0.11	3691.44	136.58
04-Mar-87	602.10	603.00	35.51	1136.23	1519.52	42.79	0.08	0.03	2257.80	83.54
20-Apr-87	602.10	603.00	37.16	1136.23	1519.52	40.89	0.11	0.11	2734.03	101.16
04-Mar-87	602.20	603.00	35.51	515.69	695.09	19.57	0.08	0.04	4131.65	152.87
20-Apr-87	602.20	603.00	37.16	515.69	695.09	18.71	0.11	0.10	5088.06	188.26
16-Dec-86	603.00	604.00	13.21	2064.62	3156.47	238.95	0.15	0.16	1935.56	71.62
15-Dec-86	603.00	605.10	13.63	1825.88	2580.35	189.31	0.12	0.12	1526.09	56.47
10-Dec-86	604.00	606.10	16.52	2005.02	3520.05	213.08	0.12	0.15	1822.27	67.42
16-Dec-86	604.00	606.10	13.21	2005.02	3520.05	266.47	0.10	0.13	1440.16	53.29
26-Jan-87	604.00	606.10	13.52	2005.02	3520.05	260.36	0.14	0.16	2030.72	75.14
30-Apr-87	607.00	608.00	33.51	1585.27	2057.12	61.39	0.07	0.07	1317.35	48.74
13-Apr-87	607.00	609.10	33.51	2579.33	3039.61	90.71	0.17	0.09	2524.96	93.42
09-Dec-86	607.00	610.00	35.92	1130.86	1497.95	41.70	0.13	0.11	3293.72	121.87
13-Apr-87	607.00	610.00	34.92	1130.86	1497.95	42.90	0.10	0.09	2450.77	90.68
09-Dec-86	607.00	611.00	35.92	6687.24	9846.51	274.12	0.15	0.11	1812.56	67.06

Cont.

Table A-5 - cont.

$$J = \frac{[Tn(2) - Tn(1) \times e^{(-L \times t)}] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x ML(Tn) ; L = (0.693 / 54.5) + Q/V

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
30-Apr-87	607.00	611.00	33.51	6824.74	8626.98	257.44	0.25	0.07	2649.62	98.04
08-Dec-86	608.00	609.10	13.21	1010.19	1080.45	81.79	0.14	0.14	1867.38	69.09
19-Jan-87	608.00	609.10	12.74	1010.19	1080.45	84.81	0.15	0.13	2003.35	74.12
30-Apr-87	608.00	611.00	33.51	5219.89	6461.69	192.83	0.25	0.07	2835.29	104.91
02-Jun-87	608.00	611.00	46.25	5219.89	6461.69	139.71	0.36	0.14	4607.82	170.49
09-Dec-86	610.00	611.00	35.92	3694.73	5158.73	143.62	0.15	0.13	2078.00	76.89
20-Jan-87	613.00	615.10	9.67	4022.35	5117.80	529.25	0.20	0.16	1858.43	68.76
21-Jan-87	613.00	614.10	11.80	4078.12	5204.94	441.10	0.09	0.18	859.35	31.80
11-Mar-87	613.00	616.00	46.48	5180.14	6291.81	135.37	0.18	0.17	2206.14	81.63
11-Mar-87	613.10	613.00	47.19	1462.30	1676.51	35.53	0.17	0.17	3982.20	147.34
26-May-87	614.00	615.10	10.01	4078.12	5204.94	519.97	0.23	0.22	2148.66	79.50
21-May-87	617.00	617.10	13.71	504.91	511.46	37.31	0.13	0.12	2661.64	98.48
20-May-87	618.00	618.10	16.52	583.73	693.50	41.98	0.08	0.11	1557.22	57.62
13-May-87	620.00	614.10	84.79	4803.69	5685.86	67.06	0.18	0.16	3003.98	111.15
02-Jun-87	621.00	608.00	27.84	3514.37	4925.73	176.93	0.14	0.10	1822.85	67.45
02-Apr-87	701.00	702.10	7.39	949.58	659.04	89.18	0.08	0.06	686.59	25.40
06-Apr-87	701.00	702.10	7.08	949.58	659.04	93.09	0.04	0.01	356.62	13.19
10-Mar-87	701.00	703.00	18.88	849.57	814.73	43.15	0.11	0.05	2171.60	80.35
08-Jan-87	703.00	704.10	11.33	1708.43	1809.14	159.68	0.09	0.07	914.56	33.84
06-Jan-87	705.00	706.10	9.44	824.10	809.80	85.78	0.13	0.13	1556.75	57.60
12-Jan-87	705.00	706.10	9.20	824.10	809.80	88.02	0.08	0.07	962.50	35.61
14-Jan-87	705.00	706.10	6.13	824.10	809.80	132.11	0.08	0.09	790.00	29.23
14-Jan-87	705.00	707.00	25.96	442.82	488.78	18.83	0.09	0.09	3269.71	120.98
18-Dec-86	801.00	802.00	76.92	3275.67	3948.11	51.33	0.57	0.48	11474.05	424.54
05-Mar-87	801.00	802.00	70.50	3275.67	3948.11	56.00	0.37	0.36	6857.49	253.73
05-May-87	801.00	802.00	80.13	3275.67	3948.11	49.27	0.36	0.39	7015.79	259.58

Table A-6 - Thoron flux calculated according to Eq. 16.
Also shown are other data of interest.

$$J = \frac{[Tn(2) - Tn(1)] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

			Q	S	V	t				
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
04-May-87	101.00	102.00	188.77	21798.78	36552.83	193.64	0.01	0.00	154.76	5.73
11-Dec-86	103.00	104.00	206.30	14872.10	28338.61	137.37	0.01	0.02	-203.56	-7.53
04-Jun-87	103.00	104.00	212.36	14872.10	28338.61	133.45	0.02	0.01	206.46	7.64
12-Dec-86	202.00	201.00	15.84	6383.38	8133.18	513.46	0.03	0.02	93.46	3.46
01-Apr-87	202.00	201.00	18.88	6383.38	8133.18	430.78	0.02	0.01	95.94	3.55
25-May-87	202.00	201.00	24.07	6383.38	8133.18	337.90	0.01	0.00	100.36	3.71
29-Dec-86	203.00	204.00	19.89	1353.36	1333.05	67.02	0.34	0.28	968.61	35.84
25-Mar-87	203.00	204.00	24.24	1353.36	1333.05	54.99	0.19	0.23	-744.89	-27.56
21-Apr-87	203.00	204.00	17.69	1353.36	1333.05	75.36	0.24	0.25	-149.01	-5.51
05-Jan-87	205.00	206.00	6.13	5549.63	6481.97	1057.42	0.58	0.31	2154.12	79.70
26-Mar-87	205.00	206.00	4.96	5549.63	6481.97	1306.85	0.28	0.26	157.46	5.83
22-Apr-87	205.00	206.00	1.89	5549.63	6481.97	3429.61	0.25	0.27	-151.92	-5.62
15-Jan-87	208.00	207.00	54.73	1165.97	1104.53	20.18	0.09	0.08	412.26	15.25
09-Apr-87	208.00	207.00	67.40	1165.97	1104.53	16.39	0.05	0.07	-996.00	-36.85
27-May-87	208.00	207.00	63.87	1165.97	1104.53	17.29	0.00	0.00	0.00	0.00
30-Dec-86	209.00	210.00	22.79	830.61	788.95	34.62	0.03	0.02	258.91	9.58
24-Mar-87	209.00	210.00	21.71	574.81	321.02	14.79	0.08	0.03	1613.64	59.70
30-Mar-87	209.00	209.10	25.77	490.04	467.93	18.16	0.11	0.05	2742.92	101.49
27-Apr-87	209.00	209.10	23.41	490.04	467.93	19.99	0.02	0.02	0.00	0.00
28-Apr-87	209.00	209.10	23.50	490.04	467.93	19.91	0.04	0.04	0.00	0.00
30-Mar-87	209.10	210.00	25.77	340.57	321.02	12.46	0.09	0.11	-1277.71	-47.28
27-Apr-87	209.10	210.00	23.41	340.57	321.02	13.71	0.05	0.02	1752.35	64.84
28-Apr-87	209.10	210.00	23.50	340.57	321.02	13.66	0.08	0.04	2344.81	86.76
28-Apr-87	210.00	211.00	23.50	560.59	673.33	28.65	0.07	0.08	-384.13	-14.21
22-Dec-86	301.00	302.00	9.44	2135.45	2181.22	231.06	0.10	0.08	177.55	6.57
09-Mar-87	301.00	302.00	9.56	2135.45	2181.22	228.16	0.05	0.03	178.25	6.60
29-Apr-87	301.00	302.00	8.73	2135.45	2181.22	249.85	0.05	0.04	86.71	3.21
01-Jun-87	301.00	302.00	4.72	2135.45	2181.22	462.12	0.05	0.02	228.21	8.44
23-Mar-87	303.00	305.30	13.57	1632.58	1575.85	116.13	0.06	0.04	224.74	8.32
23-Mar-87	303.00	308.00	19.23	7850.98	8617.20	448.11	0.03	0.04	-82.13	-3.04
14-Apr-87	303.00	308.00	18.16	3451.81	1575.85	86.78	0.07	0.03	252.09	9.33
23-Mar-87	305.30	306.10	16.75	3365.18	3699.21	220.85	0.06	0.06	0.00	0.00

Cont.

Table A-6 - cont.

$$J = \frac{[Tn(2) - Tn(1)] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
29-Jan-87	307.00	306.10	8.97	3365.18	3699.21	412.40	0.05	0.03	166.76	6.17
12-Mar-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.51	0.12	4386.49	162.30
14-May-87	402.00	401.00	4.11	1287.71	1952.83	475.14	0.46	0.19	3036.80	112.36
12-Mar-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.51	0.40	1268.89	46.95
14-May-87	403.00	402.00	4.11	1165.55	1788.44	435.14	0.46	0.43	346.06	12.80
23-Dec-86	404.00	401.00	4.72	3615.51	5861.16	1241.77	0.77	0.62	1643.92	60.83
14-May-87	404.00	401.00	4.11	3615.51	5861.16	1426.07	0.19	0.26	-761.26	-28.17
12-Mar-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.40	0.30	1215.54	44.97
14-May-87	404.00	403.00	4.11	938.49	1463.95	356.19	0.43	0.26	2066.42	76.46
18-Mar-87	405.00	405.10	0.46	390.58	395.83	860.51	0.98	0.16	5766.45	213.36
18-Mar-87	406.00	406.10	0.46	571.46	559.06	1215.36	0.96	0.48	3178.73	117.61
08-Apr-87	408.00	409.00	17.59	500.45	495.13	28.15	0.11	0.08	963.83	35.66
08-Apr-87	408.00	410.00	17.59	1158.54	1164.38	66.20	0.11	0.08	498.47	18.44
12-May-87	408.00	410.00	15.80	1158.54	1164.38	73.69	0.03	0.03	0.00	0.00
12-May-87	408.00	409.00	15.80	500.45	495.13	31.34	0.14	0.03	3224.83	119.32
12-May-87	409.00	410.00	15.80	658.09	669.24	42.36	0.03	0.14	-2587.10	-95.72
10-Jun-87	412.00	413.00	47.19	1761.14	1819.34	38.55	0.08	0.10	-515.45	-19.07
10-Jun-87	412.00	416.00	47.19	2995.52	3037.90	64.38	0.11	0.10	170.99	6.33
10-Jun-87	413.00	416.00	47.19	1234.38	1218.56	25.82	0.11	0.08	1036.25	38.34
08-Jun-87	415.00	416.00	50.97	731.68	642.15	12.60	0.13	0.12	588.58	21.78
10-Jun-87	415.00	416.00	47.19	731.68	642.15	13.61	0.11	0.08	1643.30	60.80
09-Jun-87	417.00	417.10	4.78	450.62	403.54	84.42	0.09	0.09	0.00	0.00
17-Mar-87	501.00	502.00	61.35	5792.87	6266.52	102.14	0.06	0.06	0.00	0.00
17-Dec-86	504.00	507.00	37.75	6048.76	6793.83	179.97	0.07	0.08	-106.59	-3.94
17-Mar-87	504.00	505.00	61.35	2232.73	2494.49	40.66	0.10	0.06	1067.95	39.51
17-Mar-87	504.00	506.00	61.35	4499.89	5252.96	85.62	0.11	0.08	487.54	18.04

Cont.

Table A-6 - cont.

$$J = \frac{[Tn(2) - Tn(1)] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: $Tn = 500 \times WL(Tn)$; $L = (0.693 / 54.5) + Q/V$

			Q	S	V	t				
DATE	STATION NUMBER	FORE STATION NUMBER	AVERAGE Q (m3/s)	RUBBING SURFACE (m2)	AVERAGE VOLUME (m3)	RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
17-Mar-87	505.00	506.00	61.35	2258.73	2738.22	44.63	0.11	0.10	268.98	9.95
07-Apr-87	508.00	509.00	31.89	5894.23	6737.15	211.26	0.06	0.05	102.29	3.78
07-Apr-87	510.00	511.00	31.89	5323.17	6105.46	191.45	0.07	0.04	318.91	11.80
04-Dec-86	601.00	602.00	39.01	3962.11	4847.02	124.25	0.05	0.06	-137.42	-5.08
04-Mar-87	601.00	602.10	35.51	5186.74	8597.54	242.12	0.03	0.04	-142.02	-5.25
20-Apr-87	601.00	602.10	37.16	5186.74	8597.54	231.37	0.11	0.03	1152.03	42.63
04-Mar-87	601.00	602.20	35.51	5786.36	9348.36	263.26	0.04	0.04	0.00	0.00
20-Apr-87	601.00	602.20	37.16	5786.36	9348.36	251.57	0.10	0.03	958.16	35.45
04-Dec-86	601.00	603.00	39.01	7728.98	10207.93	261.67	0.13	0.06	774.67	28.66
04-Mar-87	601.00	603.00	35.51	7728.98	10207.93	287.47	0.08	0.04	431.87	15.98
20-Apr-87	601.00	603.00	37.16	7728.98	10207.93	274.70	0.11	0.03	873.85	32.33
04-Dec-86	602.00	603.00	39.01	3749.44	5307.99	136.07	0.13	0.05	1215.47	44.97
04-Mar-87	602.10	602.20	35.51	620.54	824.43	23.22	0.04	0.03	510.34	18.88
20-Apr-87	602.10	602.20	37.16	620.54	824.43	22.19	0.10	0.11	-531.29	-19.66
04-Mar-87	602.10	603.00	35.51	1136.23	1519.52	42.79	0.08	0.03	1533.93	56.76
20-Apr-87	602.10	603.00	37.16	1136.23	1519.52	40.89	0.11	0.11	0.00	0.00
04-Mar-87	602.20	603.00	35.51	515.69	695.09	19.57	0.08	0.04	2411.69	89.23
20-Apr-87	602.20	603.00	37.16	515.69	695.09	18.71	0.11	0.10	628.16	23.24
16-Dec-86	603.00	604.00	13.21	2064.62	3156.47	238.95	0.15	0.16	-131.51	-4.87
15-Dec-86	603.00	605.10	13.63	1825.88	2580.35	189.31	0.12	0.12	0.00	0.00
10-Dec-86	604.00	606.10	16.52	2005.02	3520.05	213.08	0.12	0.15	-469.96	-17.39
16-Dec-86	604.00	606.10	13.21	2005.02	3520.05	266.47	0.10	0.13	-439.14	-16.25
26-Jan-87	604.00	606.10	13.52	2005.02	3520.05	260.36	0.14	0.16	-294.62	-10.90
30-Apr-87	607.00	608.00	33.51	1585.27	2057.12	61.39	0.07	0.07	0.00	0.00
13-Apr-87	607.00	609.10	33.51	2579.33	3039.61	90.71	0.17	0.09	1266.03	46.84
09-Dec-86	607.00	610.00	35.92	1130.86	1497.95	41.70	0.13	0.11	620.36	22.95
13-Apr-87	607.00	610.00	34.92	1130.86	1497.95	42.90	0.10	0.09	303.27	11.22
09-Dec-86	607.00	611.00	35.92	6687.24	9846.51	274.12	0.15	-0.11	487.38	18.03

Cont.

Table A-6 - cont.

$$J = \frac{[Tn(2) - Tn(1)] \times V \times L \times 1000}{S \times (1 - e^{(-L \times t)})}$$

WHERE: Tn = 500 x WL(Tn) ; L = (0.693 / 54.5) + Q/V

DATE	STATION NUMBER	FORE STATION NUMBER	Q AVERAGE Q (m3/s)	S RUBBING SURFACE (m2)	V AVERAGE VOLUME (m3)	t RETENTION TIME (s)	THORON FORE STATION (w.l.)	THORON STATION (w.l.)	J pCi/m2/s	J Bq/m2/s
30-Apr-87	607.00	611.00	33.51	6824.74	8626.98	257.44	0.25	0.07	1915.20	70.86
08-Dec-86	608.00	609.10	13.21	1010.19	1080.45	81.79	0.14	0.14	0.00	0.00
19-Jan-87	608.00	609.10	12.74	1010.19	1080.45	84.81	0.15	0.13	299.61	11.09
30-Apr-87	608.00	611.00	33.51	5219.89	6461.69	192.83	0.25	0.07	2059.68	76.21
02-Jun-87	608.00	611.00	46.25	5219.89	6461.69	139.71	0.36	0.14	2885.75	106.77
09-Dec-86	610.00	611.00	35.92	3694.73	5158.73	143.62	0.15	0.13	292.06	10.81
20-Jan-87	613.00	615.10	9.67	4022.35	5117.80	529.25	0.20	0.16	371.82	13.76
21-Jan-87	613.00	614.10	11.80	4078.12	5204.94	441.10	0.09	0.18	-861.68	-31.88
11-Mar-87	613.00	616.00	46.48	5180.14	6291.81	135.37	0.18	0.17	130.68	4.84
11-Mar-87	613.10	613.00	47.19	1462.30	1676.51	35.53	0.17	0.17	0.00	0.00
06-May-87	614.00	615.10	10.01	4078.12	5204.94	519.97	0.23	0.22	93.46	3.46
21-May-87	617.00	617.10	13.71	504.91	511.46	37.31	0.13	0.12	259.60	9.61
20-May-87	618.00	618.10	16.52	583.73	693.50	41.98	0.08	0.11	-830.20	-30.72
13-May-87	620.00	614.10	84.79	4803.69	5685.86	67.06	0.18	0.16	387.84	14.35
02-Jun-87	621.00	608.00	27.84	3514.37	4925.73	176.93	0.14	0.10	535.65	19.82
02-Apr-87	701.00	702.10	7.39	949.58	659.04	89.18	0.08	0.06	188.37	6.97
06-Apr-87	701.00	702.10	7.08	949.58	659.04	93.09	0.04	0.01	275.21	10.18
10-Mar-87	701.00	703.00	18.88	849.57	814.73	43.15	0.11	0.05	1311.17	48.51
08-Jan-87	703.00	704.10	11.33	1708.43	1809.14	159.68	0.09	0.07	211.17	7.81
06-Jan-87	705.00	706.10	9.44	824.10	809.80	85.78	0.13	0.13	0.00	0.00
12-Jan-87	705.00	706.10	9.20	824.10	809.80	88.02	0.08	0.07	134.44	4.97
14-Jan-87	705.00	706.10	6.13	824.10	809.80	132.11	0.08	0.09	-107.01	-3.96
14-Jan-87	705.00	707.00	25.96	442.82	488.78	18.83	0.09	0.09	0.00	0.00
18-Dec-86	801.00	802.00	76.92	3275.67	3948.11	51.33	0.57	0.48	2160.11	79.92
05-Mar-87	801.00	802.00	70.50	3275.67	3948.11	56.00	0.37	0.36	224.82	8.32
05-May-87	801.00	802.00	80.13	3275.67	3948.11	49.27	0.36	0.39	-742.88	-27.49